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APPARATUS USED IN DETERMINING COEFFICIENTS OF FRICTION

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The reports of research published in this magazine are necessarily qualified by the conditions of the tests from which the data are obtained. Whenever it is deemed possible to do so, generalizations are drawn from the results of the tests; and, unless this is done, the conclusions formulated must be considered as specifically pertinent only to described conditions.

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DETERMINATION OF COEFFICIENTS OF FRICTION OF SLIDING BEARINGS FOR BRIDGES

BY THE DIVISION OF TESTS, BUREAU OF PUBLIC ROADS

Reported by GEORGE W. DAVIS, Associate Engineer of Tests

EXPANSION and contraction in bridge superstructures are generally provided for by means of bearings at one end which permit the structure to move longitudinally with respect to its supports. For the smaller structures, these bearings are frequently of the sliding type in which a metal sole plate, rigidly connected to the superstructure, slides on a metal bearing which is rigidly connected to the substructure. The efficiency of these sliding bearings in preventing temperature stresses in the superstructure and overturning forces in the supporting substructure is inversely proportional to the frictional forces developed between the moving parts of the bridge.

As early as 1922 the Bureau of Public Roads, realizing the paucity of reliable test data as to the magnitude of these frictional forces, considered making an investigation. Some preliminary work was done in 1925 and in 1929 a more comprehensive series of tests was inaugurated. This program of tests, after several interruptions, has finally been completed and is made the subject of this report.

The coefficient of friction for sliding bearing plates was determined under varying pressures comparable to those usually employed in bridge design. Lateral pressure to cause slip was applied slowly and uniformly and the amount of movement at each slip was such as to approximate closely that caused by temperature changes in the field.

In making these tests several variables were considered, namely:

1. Materials.
2. Bearing pressures.
3. Surface finishes.
4. Direction of movement in relation to the direction in which the plates were finished.
5. The effect of lubrication.
6. The effect of rust.
7. The effect of electrolytic action on unlike materials in contact in the presence of salt water or salt air.

EFFECTS OF SEVERAL VARIABLES STUDIED IN INVESTIGATION

A more detailed discussion of the consideration given these variables follows.

1. *Materials.*—Fourteen different materials were used in these tests.

Bronzes:

Bronze A, A. S. T. M. Specification B22–21, class A.
Bronze B, A. S. T. M. Specification B22–21, class B.
Bronze C, A. S. T. M. Specification B22–21, class C.
Bronze D, A. S. T. M. Specification B22–21, class D.
Phosphor bronze E, A. S. T. M. Specification B22–21, class A.[1]
Phosphor bronze F, A. S. T. M. Specification B22–21, Class B.[1]
Lead bronze 22 (approximately 22 percent lead).
Lead bronze 17 (approximately 17 percent lead).
Lead bronze 8 (approximately 8 percent lead).

Steels:

Cast steel, A. S. T. M. Specification A27–24, class B, medium grade.
Rolled steel, A. S. T. M. Specification A7–29, structural steel.
Stainless steel.

Irons:

Malleable, A. S. T. M. Specification A47–30.
Cast, A. S. T. M. Specification A48–29, heavy castings.

The physical and chemical properties of these materials are shown in table 1.

2. *Bearing pressures.*—Tests were made under unit bearing pressures of 250, 500, 750, and 1,000 pounds per square inch.

3. *Surface finishes.*—Six surface finishes were used on the test specimens.

Planed finishes:

P_C—A coarse-planed finish produced by using a round-nosed tool with a radius of 1/16 inch, at a rate of 45 cutting strokes per minute, with a lateral feed of 0.018 inch per stroke, and taking a cut of 1/64 inch. This produced a somewhat coarse, striated finish.

P_M—A medium-planed finish produced with the same tool at the same rate and taking the same cut as above but using a lateral feed of 0.009 inch per stroke. This produced a medium smooth finish.

P_F—A smooth or fine-planed finish produced with a flat-nosed tool 5/8 inch wide, used at a rate of 45 strokes per minute, with a lateral feed of 1/4 inch per stroke, and taking a cut of 0.002 inch.

Rolled or planished finish:

R—Plates were finished as under P_F with a flat-nosed tool and then rolled with a hardened steel roller 3/4 inch wide and 2½ inches in diameter rigidly bolted to the head of the planer. The feed of this roller was 1/4 inch per stroke and the rate 26 strokes per minute. The roller, with its face set 0.005 inch below the surface of the specimen, was fed in 1/4-inch increments once transversely across the specimen. During this passage of the roller across the test plate all portions of the surface were rolled twice longitudinally, once on the forward stroke and once on the reverse stroke of the planer head. The roller was then depressed an additional 0.005 inch and

[1] These materials as furnished were cold rolled and were classed by the manufacturer as phosphor bronze. They actually contained less phosphorus than bronzes A, B, C, and D.

TABLE 1.—*Chemical composition and physical characteristics of materials tested*

CHEMICAL COMPOSITION [1]

	Bronzes									Steel			Iron	
	A. S. T. M. Specification B22-21				Phosphor bronze		Lead bronzes			Cast, A. S. T. M. A27-24, class B, medium	Rolled, A. S. T. M. A7-29, structural	Stainless	Malleable, A. S. T. M. A47-30	Cast, A. S. T. M. A48-29, heavy
	A	B	C	D	E	F	22 percent	17 percent	8 percent					
Copper, percent	79.45	81.95	80.17	87.43	89.20	94.30	70.38	75.70	82.00					
Tin, percent	19.87	17.17	10.66	10.30	10.55	5.16	5.36	4.96	9.06					
Lead, percent	0.05	0.10	8.47	0.32			22.33	16.90	8.37					
Zinc, percent		0.20		1.65			1.68	2.21	0.24					
Iron, percent	0.23	0.18	0.15	0.15			0.14	0.14	0.21					
Phosphorus, percent	0.40	0.35	0.55	0.15	0.09	0.14				0.42	0.011	0.028		
All others, percent		0.05			0.16	0.40	0.16	0.09	0.12					
Carbon, percent										0.375				3.230
Sulphur, percent										0.052	0.031	0.03		0.094
Manganese, percent												0.48		
Silicon, percent												0.54		
Chromium, percent												17.30		
Nickel, percent												9.62		

PHYSICAL CHARACTERISTICS [2]

	A	B	C	D	E	F	22 percent	17 percent	8 percent	Cast steel	Rolled steel	Stainless	Malleable iron	Cast iron
Compression:														
Deformation limit, pounds per square inch	30,610	17,530	11,000	10,540	28,385	26,910	9,430	7,200	13,880					
Permanent set in 1 inch under 100,000 pounds per square inch	0.136	0.190	0.378	0.268	0.124	0.185	[3] 0.507	[4] 0.544	0.320					
Tension:														
Yield point, pounds per square inch	([5])	19,225	17,330	18,050	27,630	28,520	14,355	14,000	18,335	40,865	39,230	[6]19,500–30,000	40,335	
Tensile strength, pounds per square inch	27,920	29,590	18,460	28,820	77,740	67,660	21,250	21,000	36,670	69,520	56,700	79,000–93,000	48,590	
Elongation in 2 inches, percent	0	1.00	1.75	11.00	28.00	21.00	13.00	10.00	33.00	34.00	35.70	68.0–70.0	10.17	
Reduction in area, percent										51.00		72.0–75.0		
Transverse tests:														
Deflection under 2,000 pound load, inches														0.212
Breaking load, pounds														2.97[illegible]

[1] Chemical compositions shown are from analyses of materials used.
[2] All physical data for stainless steel obtained from manufacturer.
[3] Cracked at 90,070 pounds per square inch.
[4] Cracked at 97,800 pounds per square inch.
[5] None apparent before rupture.
[6] Proportional limit.

once more passed transversely across the specimen and back again, thereby subjecting all portions of the surface of the test plate to four additional longitudinal rollings. This finish removed practically all traces of the tool marks left by the planed finish.

C.R.—The cold-rolled finish as produced by the manufacturer of the plates.

M—A milled finish produced by using a spiral mill 4 inches in diameter, 5 inches long, with a 25 degree angle, 10 teeth, and a 10-inch rake. Operating at a spindle speed of 92 revolutions per minute, a lateral feed of 115 feet per minute, and a $\frac{1}{64}$-inch cut, this mill produced a very smooth finish.

4. *Direction of movement.*—Three variations in direction of movement were used in these tests (fig. 1).

M_1—The direction of movement and the direction of finishing cuts of both plates were parallel.

M_2—The directions of finishing cuts of both plates were parallel and the direction of movement of the plates was at right angles to the finishing cuts.

M_3—The directions of the finishing cuts of the test plates were at right angles.

5. *The effect of lubrication.*—Selected combinations of plates were tested both with and without lubrication.

6. *Effect of rust.*—Cast iron specimens were exposed to weather until well rusted and then tested to determine the effect of rust.

7. *Electrolysis.*—The electrolytic action of stainless steel in contact with bronze and subjected to a salt solution and salt air was investigated.

Table 2 gives a summary of the conditions under which the tests were made.

PRECAUTIONS TAKEN TO INSURE EVEN APPLICATION OF BEARING PRESSURE AND THRUST

The coefficients of friction of the various materials were determined by means of a special apparatus designed and built by the Bureau. This device was used in conjunction with a universal testing machine and is shown schematically in figure 2. It consists essentially of a hydraulic jack for applying horizontal thrust, a calibrated beam for measuring this thrust, and the necessary steel framework for holding the various parts and the test specimens in their proper relative positions. Vertical loads or bearing pressures were applied by means of the universal testing machine, transmitted through two heavy car springs and a spherical bearing block. Two movable test plates, 4 by 4 by ⅞ inches, and two fixed plates, 4 by 4½ by ⅞ inches, were used in each test. The two fixed plates were encircled by the steel frame, which supported the calibrated beam that served as a reaction for the hydraulic jack. The two movable plates were inset in the top and bottom of a cylindrical movable member, which was free to move under the thrust exerted by the hydraulic jack.

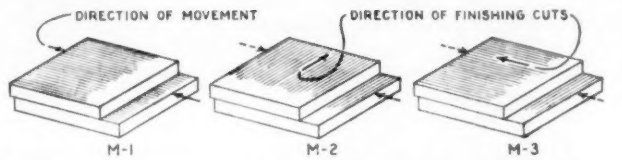

FIGURE 1.—RELATION OF DIRECTION OF MOVEMENT TO DIRECTIONS OF FINISHING CUTS FOR BEARING PLATES TESTED.

TABLE 2.—*Materials and finishes used, direction of movement, and other test conditions*

Test series	Combination of materials		Finishes used						Direction of movement			Lubrication	Number of tests
1	A	A	P_C	P_M	P_F	M	R		1	2	3	UL	30
2	B	B	P_C	P_M	P_F	M	R		1			UL	10
3	C	C	P_C	P_M	P_F	M	R		1			UL	10
4	D	D	P_C	P_M	P_F	M	R		1	2	3	UL	30
5	A	B			P_F				1			U	1
6	A	C			P_F				1			U	1
7	A	D			P_F				1			U	1
8	B	C			P_F				1			U	1
9	B	D			P_F				1			U	1
10	C	D			P_F				1			U	1
11	A	C. S.			P_F	M	R		1			UL	6
12	B	C. S.			P_F				1			U	1
13	C	C. S.			P_F				1			U	1
14	D	C. S.			P_F	M	R		1			UL	6
15	A	R. S.	P_C	P_M	P_F	M			1			UL	8
16	B	R. S.			P_F	M			1			U	2
17	C	R. S.			P_F	M			1			U	2
18	D	R. S.	P_C	P_M	P_F	M			1			UL	8
19	C. S.	C. S.	P_C		P_F	M			1	2	3	UL	18
20	C. S.	R. S.	P_C		P_F	M			1			UL	6
21	R. S.	R. S.	P_C		P_F	M			1	2	3	UL	18
22	M. I.	M. I.			P_F	M			1			UL	4
23	M. I.	C. I.			P_F	M			1			U	2
[1] 24	C. I.	C. I.			P_F	M			1			U	4
25	C. S.	M. I.			P_F	M			1			U	2
26	C. S.	C. I.			P_F	M			1			U	2
27	R. S.	M. I.			P_F	M			1			U	2
28	R. S.	C. I.			P_F	M			1			U	2
29	P. B. E.	P. B. E.		[2] P_M				C. R.	1		[2] 3	U	2
30	P. B. E.	L. B. 22		P_M					1			U	1
31	P. B. F.	P. B. F.		[2] P_M				C. R.	1		[2] 3	U	2
32	L. B. 22	L. B. 22	P_C						1			U	1
33	L. B. 17	L. B. 17	P_C						1			U	1
34	L. B. 8	L. B. 8	P_C						1			U	1
35	L. B. 22	Stl. S.		P_M					1			U	1
36	Stl. S.	C.		P_M					1			U	1
	Total												190

[1] Surfaces rusted.
[2] Symbols apply to but 1.

The symbols used are explained as follows:

Metals:
- A = Bronze A, A. S. T. M. specification B22-21, class A.
- B = Bronze B, A. S. T. M. specification B22-21, class B.
- C = Bronze C, A. S. T. M. specification B22-21, class C.
- C. I. = Cast iron, A. S. T. M. specification A48-29, heavy.
- C. S. = Cast steel, A. S. T. M. specification A27-24, class B medium.
- D = Bronze D, A. S. T. M. specification B22-21, class D.
- M. I. = Malleable iron, A. S. T. M. specification A47-30.
- L. B. 22 = Lead bronze 22 percent.
- L. B. 17 = Lead bronze 17 percent.
- L. B. 8 = Lead bronze 8 percent.
- P. B. E. = Phosphor bronze, A. S. T. M. specification B22-21, class A.
- P. B. F. = Phosphor bronze, A. S. T. M. specification B22-21, class B.
- R. S. = Rolled steel, A. S. T. M. specification A7-29, structural.
- Stl. S. = Stainless steel.

Finish:
- P_C = Coarse-planed finish.
- P_M = Medium-planed finish.
- P_F = Fine-planed finish.
- M = Milled finish.
- R = Rolled or planished finish.
- C. R. = Cold-rolled finish as manufactured.

Direction of movement:
- 1—Movement and finishing cuts parallel.
- 2—Finishing cuts parallel, movement normal to direction of finishing cuts.
- 3—Finishing cuts at right angles.

Lubrication:
- U = Unlubricated.
- UL = Tests were made with both lubricated and unlubricated plates.

The operation of the apparatus was as follows: The movable member with its two inset movable plates was placed between the two fixed plates. The desired bearing pressure was applied to the contact faces of the test plates by lowering the head of the testing machine. Horizontal thrust was then applied (by means of the hydraulic jack) to the movable member at a point midway between the contact faces of the two pairs of test plates (fig. 3). The magnitude of this thrust was

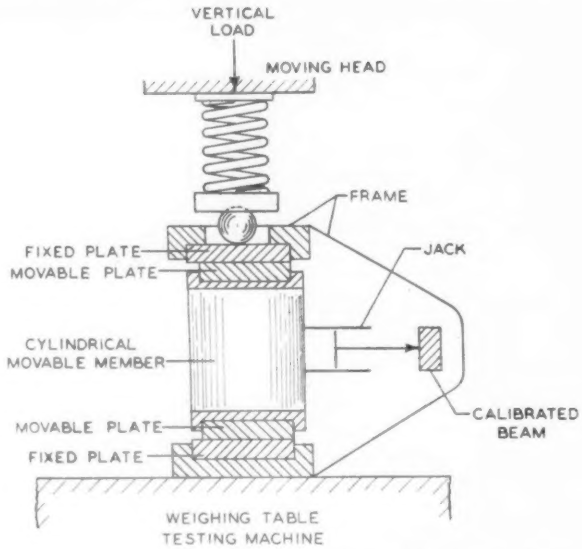

FIGURE 2.—SCHEMATIC DRAWING OF APPARATUS USED TO DETERMINE COEFFICIENT OF FRICTION.

indicated by the deflection of the calibrated beam. Since the two fixed plates were ½ inch longer, in the direction of thrust, than the two movable plates, it was possible for slip to occur and still maintain full contact between the faces.

The hydraulic jack was activated by a booster (a long-stroke, small-bore cylinder and piston) similar to those used in pressure lubrication, the system being first filled by means of a conventional hydraulic pump. The use of the booster to apply the final pressure to cause slip allowed a steady pressure to be applied without the pulsations usually caused by the strokes of a pump. The interposition of the two heavy car springs between the head of the testing machine and the bearing blocks prevented oscillation of the beam of the testing machine during tests.

The deflection of the calibrated beam was measured by means of a micrometer dial graduated to 1/10000-inch divisions, one division on the dial being equivalent to 22 pounds of thrusting force. Inasmuch as the horizontal thrust measured by the calibrated beam was forced to overcome the friction existing between the contact faces of the two pairs of test plates under known unit bearing pressures, the thrust applied to each pair of plates was only one-half of that indicated by the dial reading.

The total thrusts required to overcome the initial frictional resistance under each of the unit bearing pressures were used in determining the coefficient of friction.

Definitions of the nomenclature used in this report are as follows:

Slip.—A single movement of the movable plates under lateral thrust while subject to some known bearing pressure was termed a slip.

Test.—A test comprised 15 sets of 20 slips, i. e., 300 independent slips under each of the unit bearing pressures used, other variables such as materials, finish, direction of movement, and state of lubrication being constant.

Test series.—A test series is composed of all tests made of any one combination of materials under varying conditions of finish, direction of movement, and state of lubrication.

INVESTIGATION INCLUDED STUDY OF UNLUBRICATED, LUBRICATED AND RUSTED PLATES

Tests of unlubricated plates.—In all tests the two movable plates were 4 by 4 by ⅞ inches and the two fixed plates were 4 by 4½ by ⅞ inches. In each test newly surfaced plates were used. Before testing, the plates were thoroughly washed in naphtha to remove surface grease, moisture, or any foreign matter. The plates were then inserted in the testing apparatus and a bearing load of 4,000 pounds (250 pounds per square inch, on the 16 square inches of contact area of the plates) was imposed by lowering the head of the testing machine. Thrust was then applied through the hydraulic jack by means of the booster until slip occurred. The point of slip was considered to be that point at which the needle of the micrometer dial started to recede. Successive thrusts were applied and readings noted until a succession of 20 slips had been recorded. Each set of 20 slips caused a shifting of the movable plates over the fixed plates of approximately ½ inch.

After each set, the plates were removed, rinsed in naphtha, turned horizontally through 180 degrees and replaced in the apparatus. The plates were thus kept free from lubricant and were subjected to sliding in opposite directions as would be the case in actual service. After 15 sets of 20 slips the bearing pressure was increasd to the next higher value. The schedule just described was carried out for bearing pressures of 250, 500, 750, and 1,000 pounds per square inch, respectively, and this constituted one test, the plates being resurfaced before being used again.

In every case where seizure was apparent the fact was noted, in order that the percentage of movements or slips in which seizure occurred during the course of each test might be determined. Seizure was determined either by audible chattering or by jumping of the plates as indicated by the micrometer dial. The thicknesses of all plates were measured by means of micrometer calipers at four points both before and after each test.

Tests of lubricated plates.—The procedure followed in making tests of lubricated plates was identical with that used in testing unlubricated plates with the following exceptions. After the newly surfaced plates were washed in naphtha a thin coating of graphite cup grease was applied to their contact faces. They were placed in the testing apparatus and a bearing pressure of 4,000 pounds, or 250 pounds per square inch, was applied. The plates were slid in successive slips once across the fixed plates to distribute the grease evenly and to force any excess from between the plates. The plates were then removed, reversed, and successive slips were made as in the tests of unlubricated plates, but with the original coating of lubricant intact.

Four cast-iron plates with the smooth-planed finish (PF) and four with a milled finish (M) were exposed to the weather, including snow and rain, for 76 and 56 days, respectively. This exposure produced a thick coating of rust. The plates were rubbed against each other with hand pressure to remove superficial rust and the friction tests were then made. The friction developed in both cases was so large that only the lowest unit bearing pressure (250 pounds per square inch) was applied. The plates were reversed between each set of 20 slips, and the rust loosened from the contact surfaces was lightly brushed off with a cloth between each series of slips. A comparison of the thickness of these plates as measured before and after exposure to the weather and after friction tests had been completed indicated that the wear shown during the tests was caused by the loosening of surface rust, as no measurable reduction in original thickness was noted.

The following procedure was adopted in determining the coefficient of friction in each test. Curves were plotted for each of the four loadings, mean values of the total thrust necessary to overcome the friction existing on the 16 square inches of bearing surface, for each of the 15 sets of 20 slips, being used as ordinates, while the 15 sets were plotted at uniform spacings as abscissae.

COEFFICIENT OF FRICTION REMAINED CONSTANT UNDER VARIOUS BEARING PRESSURES

The averages of the mean values of thrust of the last 10 sets (200 individual slips) were used in determining the coefficient of friction, the first 5 sets being considered as adjusting or wearing-in values. These averages were plotted on abscissa, proportional to the bearing pressures and a mean curve was drawn through the resulting four points and the zero point. In all cases this curve was a straight line, which indicates that the value of the coefficient of friction remains constant under varying unit pressures. The maximum and minimum variations above and below the mean of any set of slips were shown by the limits of the vertical lines, drawn to scale, extending above and below the mean values as plotted.

It obviously being impracticable to reproduce the curves representing all tests performed in this investigation, typical curves developed in the manner just described are shown in figures 4, 5, 6, and 7. The results of all tests are compiled in table 3 in ascending order of coefficients of friction for tests without lubrication. In the column headed "Average maximum variations from mean thrust", the values shown were derived as follows: The average of the thrusting forces necessary to cause movement for the last 10 sets of slips, or of 200 individual slips, under a unit bearing pressure of 500 pounds per square inch, was used as a base. The maximum variations in thrusting force above and below the mean thrust for each of the last 10 sets of slips were averaged and these two averages expressed as plus or minus percentages of the base.

The values shown for the variations from mean thrust are for the 500 pounds per square inch unit pressure only, as this value is considered to be a representative value for all loadings. Variations for the tests of lubricated plates are omitted. In the majority of cases the variation for the lubricated plates was greater than in the case of unlubricated plates.

For the purpose of discussion, results for the 111 combinations tested, as arranged in table 3 and excluding the two tests of rusted plates (24–2 and 24–4) were arbitrarily divided into three equal groups of 37 combinations each. These groups are designated 1, 2, and 3, and contain the low, intermediate, and high values of the coefficient of friction, respectively.

In determining the effect of lubrication on the value of the coefficient of friction between flat plates, data from 77 tests both with and without lubrication were available for comparison. Examination of the individual curves for each of these 77 tests gave the following indications.

TABLE 3.—*Coefficients of friction and other data for the various plates tested*

GROUP 1—LOW COEFFICIENTS OF FRICTION

Series and test number [1]	Metals used	Surface finish	Direction of movement	Coefficient of friction: Lubricated	Coefficient of friction: No lubrication	Average maximum variations from mean thrust; 500 pounds per square inch unit bearing pressure; no lubrication: +	Average maximum variations: −	Wear: Lubricated	Wear: No lubrication	Seizure—Percentage of slips seized: Lubricated—Unit bearing pressure— 250 pounds	Lubricated 500 pounds	Lubricated 750 pounds	Lubricated 1,000 pounds	No lubrication—Unit bearing pressure— 250 pounds	No lubrication 500 pounds	No lubrication 750 pounds	No lubrication 1,000 pounds
						Percent	*Percent*	*Inches*	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
17-1	C-R. S.	P_F	1		0.106	2.1	1.0										
35-1	L. B. 22-Stl. S.	P_M	1		.110	4.0	2.4										
13-1	C-C. S.	P_F	1		.112	1.7	1.4										
36-1	C-Stl. S.	P_M	1		.116	2.5	1.3										
17-2	C-R. S.	M	1		.118	3.2	1.4										
15-5-6	A-R. S.	P_F	1	0.121	.123	1.1	1.5										
15-7-8	A-R. S.	M	1	.110	.127	1.1	.7										
16-1	B-R. S.	P_F	1		.128	1.6	1.5										
15-3-4	A-R. S.	P_M	1	.122	.128	1.7	1.9										
32-1	L. B. 22-L. B. 22.	P_C	1		.128	1.8	1.5		0.001								
33-1	L. B. 17-L. B. 17.	P_C	1		.130	1.0	2.7		F=0 M=.0005								
30-1	P. B. E.-L. B. 22.	P_M	1		.132	3.3	1.7										
34-1	L. B. 8-L. B. 8.	P_C	1		.132	1.4	1.4										
16-2	B-R. S.	M	1		.132	.7	1.6										
11-1-2	A-C. S.	P_F	1	.115	.134	2.6	1.0		A=0 C. S.=.001								
6-1	A-C.	P_F	1		.134	1.2	3.6										
11-5-6	A-C. S.	R	1	.123	.135	2.9	1.3										
18-7-8	D-R. S.	M	1	.108	.135	.7	1.1										
12-1	B-C. S.	P_F	1		.136	1.0	2.4										
18-1-2	D-R. S.	P_C	1	.121	.137	1.4	.9		D=.001 R. S.=.002								
3-3-4	C-C.	P_M	1	.126	.137	1.3	1.3			2	12	16	21				
11-3-4	A-C. S.	M	1	.112	.138	1.2	1.0										
15-1-2	A-R. S.	P_C	1	.116	.138	2.8	1.2		A=.001 R. S.=.002								
1-7-8	A-A.	P_M	1	.126	.138	1.4	2.7										
5-1	A-B.	P_F	1		.138	1.1	2.5										
8-1	B-C.	P_F	1		.139	1.8	2.4										
4-19-20	D-D.	M	1	.110	.140	1.4	2.1										
14-3-4	D-C. S.	M	1	.110	.140	1.3	1.9										
1-15-16	A-A.	P_F	2	.162	.143	3.1	3.8			19	31	25	18				
1-29-30	A-A.	R	3	.122	.146	1.7	1.2										17
4-21-22	D-D.	M	2	.112	.146	1.5	4.6										
4-23-24	D-D.	M	3	.122	.146	1.5	1.6										
9-1	B-D.	P_F	1		.148	1.5	4.1										
3-9-10	C-C.	R	1	[2] .185	.148	1.4	1.9			52	89	92	94	0	12	12	12
1-19-20	A-A.	M	1	.107	.148	.9	1.8										
2-3-4	B-B.	P_M	1	.148	.150	1.1	2.8										
3-7-8	C-C.	M	1	.164	.150	1.1	1.2			4	14	38	38				

GROUP 2—INTERMEDIATE COEFFICIENTS OF FRICTION

Series and test number [1]	Metals used	Surface finish	Direction of movement	Coefficient of friction: Lubricated	Coefficient of friction: No lubrication	Average maximum variations: +	Average maximum variations: −	Wear: Lubricated	Wear: No lubrication	Lubricated 250 pounds	Lubricated 500 pounds	Lubricated 750 pounds	Lubricated 1,000 pounds	No lubrication 250 pounds	No lubrication 500 pounds	No lubrication 750 pounds	No lubrication 1,000 pounds
14-1-2	D-C. S.	P_F	1	0.121	0.150	0.9	2.1										
1-5-6	A-A.	P_C	3	.139	.150	3.0	1.2										
19-15-16	C. S.-C. S.	M	2	.136	.150	4.0	4.5		0.001					0	1	12	35
24-3	C. I.-C. I.	M	1		.150	2.9	4.5									39	25
1-11-12	A-A.	P_M	3	.132	.151	1.2	.9										
7-1	A-D.	P_F	1		.152	1.5	3.0										
4-7-8	D-D.	P_M	1	.148	.152	1.0	2.0										
1-13-14	A-A.	P_F	1	.128	.152	1.3	1.6										
1-17-18	A-A.	P_F	3	.134	.154	1.7	1.4										2
1-23-24	A-A.	M	3	.128	.154	.9	1.4									2	9
1-25-26	A-A.	R	1	.146	.157	1.7	2.3										
24-1	C. I.-C. I.	P_F	1		.157	4.2	4.8									4	12
1-1-2	A-A.	P_C	1	.132	.157	1.5	.9		F=0 M=.002								
4-5-6	D-D.	P_C	3	.154	.158	7.5	1.9		.001								
18-3-4	D-R. S.	P_M	1	.134	.158	2.4	4.0		.001								
3-5-6	C-C.	P_F	1	[3] .190	.158	1.4	2.4			73	81	97	100				
25-2	C. S.-M. I.	M	1		.158	4.7	7.0							0	5	24	26
18-5-6	D-R. S.	P_F	1	.118	.159	1.0	2.6										
1-9-10	A-A.	P_M	2	.136	.161	17.3	7.5		F=0 M=.001	3	48	57	45	96	97	98	88
2-1-2	B-B.	P_C	1	.144	.161	2.1	1.7	.001									
2-5-6	B-B.	P_F	1	.154	.162	1.0	2.3										
22-1-2	M. I.-M. I.	P_F	1	.152	.162	5.3	6.8							0	4	45	54
1-21-22	A-A.	M	2	.125	.162	2.1	1.4										
19-17-18	C. S.-C. S.	M	3	.144	.162	8.8	6.5							5	9	35	53
31-1	P. B. F.-P. B. F.	C. R.	1		.162	3.5	2.8										
4-1-2	D-D.	P_C	1	.130	.163	1.9	1.4										
1-27-28	A-A.	R	2	.124	.164	2.2	3.2										29
10-1	C-D.	P_F	1		.165	1.8	2.9										
4-11-12	D-D.	P_M	3	.162	.166	1.3	1.5										
2-7-8	B-B.	M	1	.121	.167	1.2	1.8										
25-1	C. S.-M. I.	P_F	1		.167	4.9	3.7							33	56	60	70
4-27-28	D-D.	R	2	.130	.168	2.3	5.3							0	13	44	66
31-2	P. B. F.-P. B. F.	P_M	3		.170	2.7	2.6							0	11	60	89
3-1-2	C-C.	P_C	1	.161	.172	.9	.5	.002									
4-9-10	D-D.	P_M	2	.142	.172	7.9	6.5		F=0 M=.001	10	39	39	48	100	100	100	100
2-9-10	B-B.	R	1	.132	.172	1.6	.9							0	0	1	33
4-25-26	D-D.	R	1	.091	.172	1.6	1.9										

[1] First number indicates series; remaining numbers indicate individual tests. Where 2 test numbers are shown, they refer to tests of lubricated and unlubricated plates respectively.

[2] Lubricant removed, coefficient of friction dropped to 0.170.

[3] Lubricant removed, coefficient of friction dropped to 0.152.

TABLE 3.—*Coefficients of friction and other data for the various plates tested*—Continued

GROUP 3—HIGH COEFFICIENTS OF FRICTION

Series and test number	Metals used	Surface finish	Direction of movement	Coefficient of friction: Lubricated	Coefficient of friction: No lubrication	Average maximum variations from mean thrust; 500 pounds per square inch unit bearing pressure; no lubrication: +	−	Wear: Lubricated	Wear: No lubrication	Seizure—Percentage of slips seized: Lubricated—Unit bearing pressure—250 pounds	500 pounds	750 pounds	1,000 pounds	No lubrication—Unit bearing pressure—250 pounds	500 pounds	750 pounds	1,000 pounds
						Percent	Percent	Inches	Inches	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
21-17-18	R. S.-R. S.	M	3	0.141	0.174	13.2	12.0							19	43	42	70
14-5-6	D-C. S.	R	1	.110	.174	2.5	5.1										
19-1-2	C. S.-C. S.	P_C	1	.150	.174	8.7	3.2	0.001	0.002	0	5	10	26	1	1	2	12
23-1	M. I.-C. I.	P_F	1		.174	2.0	4.6		M. I.=.001; C. I.=0					0	0	18	9
23-2	M. I.-C. I.	M	1		.174	6.8	2.2										
29-2	P. B. E.-P. B. E.	P_M	3		.175	2.2	4.4							0	8	82	87
21-15-16	R. S.-R. S.	M	2	.140	.176	17.1	12.1							34	41	75	58
22-3-4	M. I.-M. I.	M	1	.135	.178	8.6	5.9							31	40	49	53
20-5-6	C. S.-R. S.	M	1	.130	.182	11.6	7.8							49	76	75	79
27-2	R. S.-M. I.	M	1		.182	7.5	5.3							52	63	78	71
27-1	R. S.-M. I.	P_F	1		.183	14.8	9.6							43	62	77	79
19-13-14	C. S.-C. S.	M	1	.131	.186	12.2	7.4		.001					36	55	76	80
19-11-12	C. S.-C. S.	P_F	3	.145	.187	19.8	10.6						2	42	69	83	92
4-15-16	D-D	P_F	2	.162	.190	4.0	5.5							0	46	78	78
19-5-6	C. S.-C. S.	P_C	3	.150	.190	16.7	13.4	.001	F=.001; M=.002	10	14	22	44	15	40	54	57
4-29-30	D-D	R	3	.134	.194	2.0	3.5							0	26	63	72
29-1	P. B. E.-P. B. E.	C. R.	1		.195	8.4	7.6							0	2	3	6
19-9-10	C. S.-C. S.	P_F	2	.141	.198	17.8	9.9							29	87	91	93
26-2	C. S.-C. I.	M	1		.203	1.6	3.3							0	18	58	77
4-17-18	D-D	P_F	3	.176	.204	5.4	10.4	F=0; M=.001						6	57	61	79
20-1-2	C. S.-R. S.	P_C	1	.160	.208	13.0	9.7	.001	.002	10	10	21	30	0	17	35	
4-13-14	D-D	P_F	1	.144	.210	4.7	9.5		.001					63	78	84	85
21-5-6	R. S.-R. S.	P_C	3	.166	.211	17.9	13.0		.001	8	15	43		25	56	66	
21-13-14	R. S.-R. S.	M	1	.134	.215	15.0	17.6							23	48	77	93
19-7-8	C. S.-C. S.	P_F	1	.140	.218	18.2	15.3							54	81	90	
21-11-12	R. S.-R. S.	P_F	3	.165	.220	19.0	14.7			38	68	72	76	80	89	90	
26-1	C. S.-C. I.	P_F	1		.220	15.9	17.2							70	78	89	
21-1-2	R. S.-R. S.	P_C	1	.154	.224	16.8	16.0	F=0; M=.001	.001	6	15	26	35	19	59	66	
20-3-4	C. S.-R. S.	P_F	1	.160	.238	17.4	16.8			6	26	52	63	94	93	97	
28-2	R. S.-C. I.	M	1		.239	8.7	4.8		C. I.=0; R. S.=.001					81	86	93	
21-9-10	R. S.-R. S.	P_F	2	.156	.243	12.6	13.4			3	8	13	56	28	64	81	
21-7-8	R. S.-R. S.	P_F	1	.155	.266	12.8	16.6			2	8	49	63	69	88	98	
28-1	R. S.-C. I.	P_F	1		.275	9.4	11.0		C. I.=0; R. S.=.001					87	92	90	
1-3-4	A-A	P_C	2	.320	.390	Seized				100				100			
19-3-4	C. S.-C. S.	P_C	2	.244	.392	Seized		.001		92				100			
4-3-4	D-D	P_C	2	.210	.448	Seized				92				100			
21-3-4	R. S.-R. S.	P_C	2	.356	.456	Seized		F=0; M=.001	F=0; M=.001	100				100			

TESTS OF RUSTED PLATES

Series and test number	Metals used	Surface finish	Direction of movement	Coefficient of friction: Lubricated	Coefficient of friction: No lubrication	+	−	Wear: Lubricated	Wear: No lubrication	Lub. 250 pounds	500 pounds	750 pounds	1,000 pounds	No lub. 250 pounds	500 pounds	750 pounds	1,000 pounds
24-4	C. I.-C. I.	M	1		[4] .488	Seized			[5] .001					100			
24-2	C. I.-C. I.	P_F	1		[4] .598	Seized			[5] .002					97			

[4] Surfaces rusted by exposure

[5] Rust only wore off, no decrease in original thickness.

The symbols used are explained as follows:

Metals—
- A=Bronze, A. S. T. M. Specification B22-21, class A.
- B=Bronze, A. S. T. M. Specification B22-21, class B.
- C=Bronze, A. S. T. M. Specification B22-21, class C.
- C. I.=Cast iron, A. S. T. M. Specification A48-29, heavy.
- C. S.=Cast steel, A. S. T. M. Specification A27-24, class B medium.
- D=Bronze, A. S. T. M. Specification B22-21, class D.
- L. B. 22=Lead bronze-22 percent lead.
- L. B. 17=Lead bronze-17 percent lead.
- L. B. 8=Lead bronze-8 percent lead.

Metals—Continued.
- M. I.=Malleable iron, A. S. T. M. Specification A47-30.
- P. B. E.=Phosphor bronze, A. S. T. M. Specification B22-21, class A.
- P. B. F.=Phosphor bronze, A. S. T. M. Specification B22-21, class B.
- R. S.=Rolled steel, A. S. T. M. Specification A7-29, structural grade.
- Stl. S.=Stainless steel.

Wear—
- M=Movable plate.
- F=Fixed plate.

Direction of movement—
- 1=Direction of movement and direction of finishing cuts parallel.
- 2=Direction of movement at right angles to finishing cuts, finishing cuts parallel.
- 3=Direction of the finishing cuts at right angles.

In 60 tests of unlubricated plates the mean values of the coefficient of friction, for the last 10 sets of slips under each of the four loads, showed a tendency to remain constant or to decrease slightly, and in 17 tests this value showed a tendency to increase slightly, while in the tests of lubricated plates this value for 44 remained constant or decreased and 33 showed a marked tendency to increase.

Figure 7 shows data from one of the tests in which this tendency for the resistance to increase as the test progressed is evident. The example given is a typical rather than an extreme case.

In four tests (1-15-16, 3-5-6, 3-7-8, and 3-9-10) the lubricated plates showed greater friction than the unlubricated plates, and in all four cases the lubricated plates seized while unlubricated plates seized in only

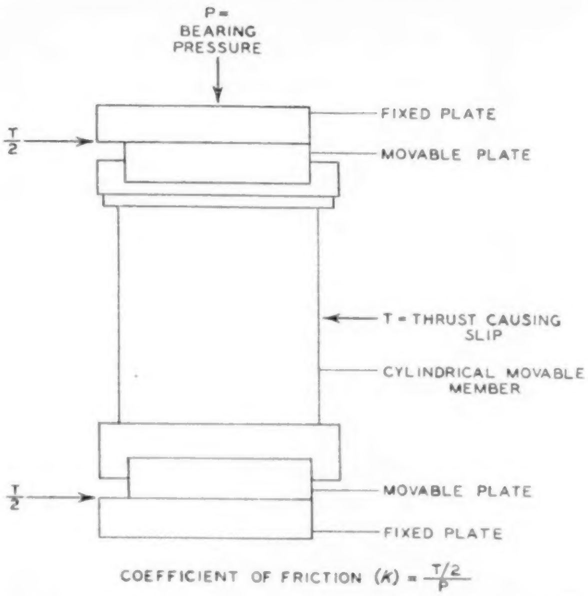

Figure 3.—Arrangement of Bearing Plates During Test, Showing the Forces Involved in Calculating the Coefficient of Friction (k).

one case. In two tests (3–5–6 and 3–9–10), where the friction with lubrication was greater than without lubrication, all lubricant was washed off with naphtha at the end of the tests and a single set of 20 slips under each of the four loadings was run without lubricant. These results showed a definite decrease in the coefficients of friction (from 0.190 and 0.185, when lubricated, to 0.152 and 0.170, respectively) with no lubrication.

In group 1 of table 3 there were 21 combinations that were tested both with and without lubrication. Of these 21 combinations, the coefficients of friction of the lubricated plates in 6 cases showed a tendency to increase and in 15 cases a tendency to remain constant as the tests progressed, while in the same 21 combinations, where unlubricated plates were used, only 2 cases showed a tendency to increase, 16 remained constant, and 3 decreased.

In group 2 of table 3 there were 29 combinations available for a similar comparison. In these 29 tests the tendencies of the coefficients of friction to vary were as follows: When lubricated plates were used, 18 showed a tendency to increase, 10 to remain constant, and 1 to decrease. With no lubrication, 3 combinations showed a tendency to increase, 23 to remain constant, and 3 to decrease.

In group 3 of table 3, 27 combinations were available for comparison and the following tendencies to vary were noted. With lubricated plates 9 combinations showed a tendency to increase, 17 to remain constant, and 1 to decrease. With the unlubricated plates, 12 combinations showed a tendency to increase, 12 to remain constant, and 3 to decrease.

LUBRICANT OF QUESTIONABLE PERMANENT VALUE IN REDUCING FRICTION

Considering groups 1 and 2, as comprising the most desirable combinations, table 4 shows the general tendencies of the coefficients to vary and permits a comparison to be made between the lubricated and unlubricated plates in this respect.

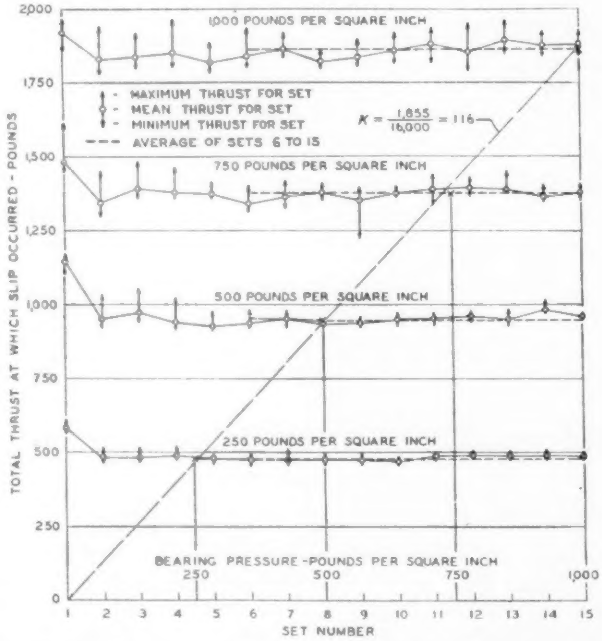

Figure 4.—Relations Between Bearing Pressure and Thrust at Which Slip Occurred for Test Series 36, No. 1, Showing Derivation of Coefficient of Friction (k): Bronze C on Stainless Steel; Medium-planed Finish; Movement Parallel to Finishing Cuts; No Lubrication; No Wear; and No Seizure.

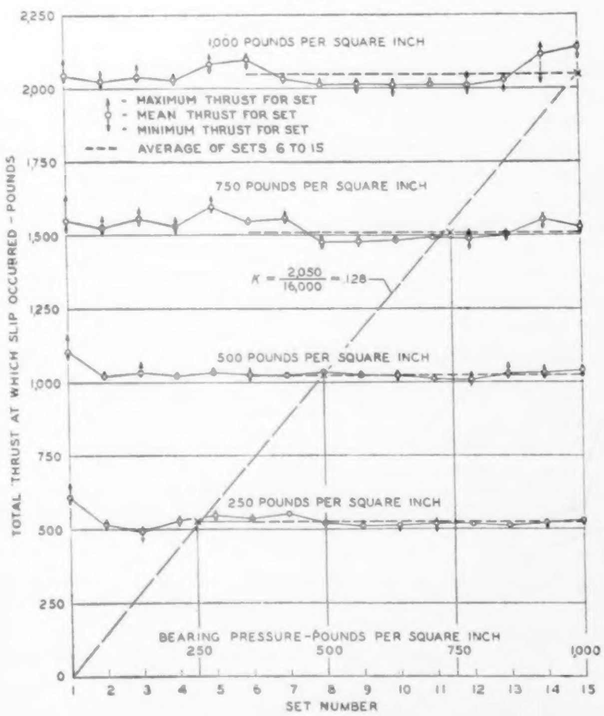

Figure 5.—Relations Between Bearing Pressure and Thrust at Which Slip Occurred for Test Series 16, No. 1. Bronze B on Rolled Steel; Fine-planed Finish; Movement Parallel to Finishing Cuts; No Lubrication; No Wear; and No Seizure.

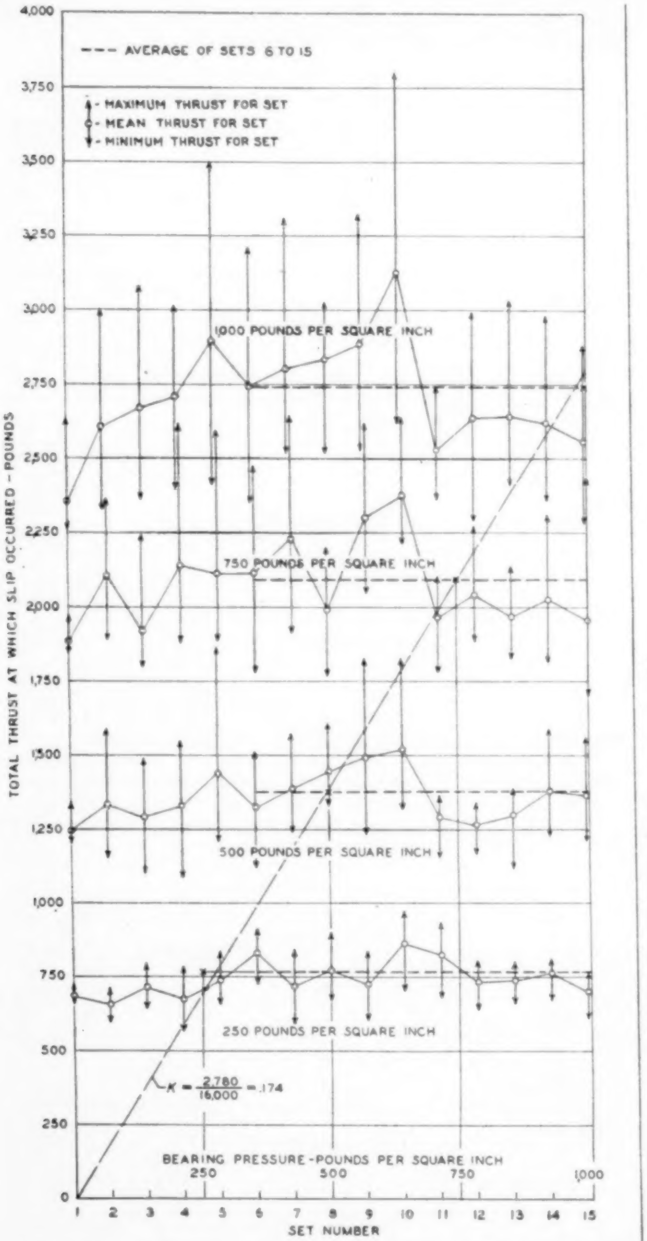

Figure 6.—Relations Between Bearing Pressure and Thrust at Which Slip Occurred for Test Series 21, No. 17. Rolled Steel on Rolled Steel; Milled Finish; Movement—Finishing Cuts at Right Angles; No Lubrication; No Wear; Seizure at 250 Pounds Per Square Inch, 19 Percent of Slips; at 500 Pounds, 43 Percent; at 750 Pounds, 42 Percent; and at 1,000 Pounds per square Inch, 70 Percent of Slips.

Table 4.—*Variations in coefficient of friction in tests of lubricated and unlubricated plates*

Condition of plates	Variation in coefficient of friction during last 20 sets of slips		
	Constant	Increased	Decreased
	Number of tests	*Number of tests*	*Number of tests*
Unlubricated	39	5	6
Lubricated	25	24	1

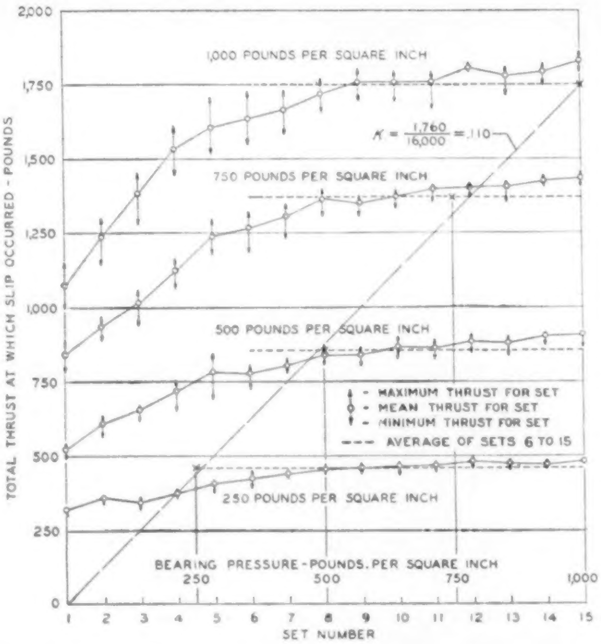

Figure 7.—Relations Between Bearing Pressure and Thrust at Which Slip Occurred for Test Series 14, No. 6. Bronze D on Cast Steel; Rolled or Planished Finish; Movement Parallel to Finishing Cuts; Plates Lubricated; No Wear; and No Seizure.

In group 1, the values for the lubricated plates are on an average 11.5 percent less than the values for the unlubricated plates, while in groups 2 and 3 the differences in favor of the lubricated plates are 13.8 percent and 28.3 percent, respectively.

It appears that, although lubrication with the type of lubricant used causes an initial decrease in friction, with continued movement the lubricant is forced out from between the plates and the friction increases until it may equal or surpass that of the unlubricated plates. The smoother the finish, the sooner the beneficial effects of lubrication appear to be dissipated.

Inasmuch as the beneficial effects of lubrication for the most desirable combinations (groups 1 and 2) are small and since in many of the tests these effects decreased during the comparatively limited number of movements made in a test, it seems probable that the use of a single application of graphite grease, or other lubricant which will flow, is of but little, if any, permanent value when used between flat plates subject to load intensities such as used in these tests.

In considering the effects of surface finish on friction, 19 groups of tests with machined surfaces are available for comparison. In making the comparison, tests of unlubricated plates, with direction of movement and direction of finishing cuts parallel, were used. The results of these tests are assembled in table 5 in four groups:

1. Like metals (ferrous).
2. Unlike metals (ferrous).
3. Like metals (bronze).
4. Unlike metals (ferrous and bronze).

In groups 1 and 2 the fine-planed finish gave the highest values of the coefficient of friction and the milled finish gave the lowest values except in the case of cast iron on cast iron, for which the lowest value was

TABLE 5.—*Effect of surface finish on magnitude of coefficient of friction; all plates unlubricated; direction of movement and direction of finish parallel*

GROUP 1—LIKE METALS—FERROUS

Metals	Finish	Coefficient of friction (k)	Seizure
R. S.	P_F	0.266	Yes.
	P_C	.224	Yes.
	M	.215	Yes.
C. S.	P_F	.218	Yes.
	M	.186	Yes.
	P_C	.174	Yes.
C. I.	P_F	.157	Yes.
	M	.150	Yes.

GROUP 2—UNLIKE METALS—FERROUS

Metals	Finish	Coefficient of friction (k)	Seizure
R. S.-C. I.	P_F	0.275	Yes.
	M	.239	Yes.
C. S.-R. S.	P_F	.238	Yes.
	P_C	.208	Yes.
	M	.182	Yes.
C. S.-C. I.	P_F	.220	Yes.
	M	.203	Yes.
R. S.-M. I.	P_F	.183	Yes.
	M	.182	Yes.
M. I.-C. I.	P_F	.174	Yes.
	M	.174	No.
C. S.-M. I.	P_F	.167	Yes.
	M	.158	Yes.

GROUP 3—LIKE METALS—BRONZE

Metals	Finish	Coefficient of friction (k)	Seizure
D.	P_F	0.210	Yes.
	R	.172	No.
	P_C	.163	No.
	P_M	.152	No.
	M	.140	No.
[illegible]	R	.172	Yes.
	M	.167	No.
	P_F	.162	No.
	P_C	.161	No.
	P_M	.150	No.
[illegible]	P_C	.172	No.
	P_F	.158	No.
	M	.150	No.
	R	.148	Yes.
	P_M	.137	No.
A.	P_C	.157	No.
	R	.157	No.
	P_F	.152	No.
	M	.148	No.
	P_M	.138	No.

GROUP 4—UNLIKE METALS—FERROUS AND BRONZE

Metals	Finish	Coefficient of friction (k)	Seizure
D-C. S.	R	0.174	No.
	P_F	.150	No.
	M	.140	No.
D-R. S.	P_F	.159	No.
	P_M	.158	No.
	P_C	.137	No.
	M	.135	No.
A-R. S.	P_C	.138	No.
	P_M	.128	No.
	M	.127	No.
	P_F	.123	No.
A-C. S.	M	.138	No.
	R	.135	No.
	P_F	.134	No.
B-R. S.	M	.132	No.
	P_F	.128	No.
C-R. S.	M	.118	No.
	P_F	.106	No.

Symbols used are:
A = Bronze A.
B = Bronze B.
C = Bronze C.
D = Bronze D.
C. I. = Cast iron.
C. S. = Cast steel.
M. I. = Malleable iron.
R. S. = Rolled steel.

given by the coarse-planed finish. Seizure was noted in 100 percent of the tests in group 1 and 92 percent of those in group 2.

In group 3 either the medium-planed or the milled finishes had the lowest values of the coefficient of friction. Seizure was noted in only 15 percent of the 20 tests comprising this group.

In group 4 the fine-planed and milled finishes gave the most satisfactory results. No seizure was noted in this group.

Tests were made of combinations of two grades of cold-rolled phosphor bronze, with surfaces as rolled at the mill. In both cases the direction of movement and the directions of finish of all plates were parallel. Phosphor bronze E showed a high coefficient of friction, falling within the highest 20 percent of all tests made. Seizure was noted in 6 percent of the slips under the maximum loads. Phosphor bronze F, under similar conditions of test, gave a coefficient of friction within the higher 50 percent of all tests made, and no seizure was noted.

An attempt to determine the comparative merits of a cold-rolled finish and a machined finish was later made. The cold-rolled phosphor bronze specimens, both E and F, were machined with a medium-planed finish (P_M) and tested in like pairs. No lubrication was used and tests were made with the direction of the finishing cuts of the contact faces at right angles (M_3). Data from former tests indicated the above finish and direction of movement to be satisfactory for use with like bronzes.

The results of these tests (series 29 and 31) are shown in the general compilation of test results in table 3. By comparing the results it will be seen that no wear was apparent in any of these tests. In the case of phosphor bronze E, the machined surfaces showed a 10-percent decrease in friction when compared with the cold-rolled finish, while in the case of phosphor bronze F the machined plates showed approximately a 5-percent increase in friction in comparison with the cold-rolled plates. Both materials, when tested with machined surfaces, showed a marked increase in the number of slips which seized, from a maximum of 6 percent to 87 percent in series 29 and from a maximum of 0 percent to 89 percent in series 31. However, the intensity of seizure, as evidenced by the lack of violence of the jump and the small distances moved under lateral thrust, was low in both tests. The percentage of maximum variation from the mean thrust at slip was lower when machined surfaces were used than when cold-rolled surfaces were used.

If due consideration is given to the variations from the mean thrust necessary to cause slip found in the several tests, and to the limited number of comparisons made for the two finishes, the limited differences in coefficient of friction found indicate no marked superiority for either finish.

MILLED FINISH WITH FINISHING CUTS AT RIGHT ANGLES FOUND MOST SATISFACTORY

Two tests were made of cast-iron plates, one with a fine-planed surface and one with a milled finish, all surfaces rusted by exposure to weather. The friction developed was excessive in both series and only under the lowest unit bearing pressure used (250 pounds per square inch) could slipping be produced.

From the results shown in table 5 the following conclusions seem reasonable:

1. A milled finish is most satisfactory when ferrous materials are used in combination.
2. A milled or medium-planed finish is most satisfactory for combinations of like bronzes.

107715—36——2

3. A milled or fine-planed finish is most satisfactory for combinations of ferrous materials with bronzes.

In connection with these conclusions, it should be remarked that the spread of values resulting from differences in surface finish is, in general, not great and in many cases the differences between average coefficients of friction for two or more finishes on a particular combination of metals are so small as to lack significance. Fine distinctions are therefore not warranted.

There are available for purposes of comparison 16 groups of tests in which all three directions of movement were tested with the same combinations of materials. Fourteen of these groups covered the three planed and milled finishes and two groups covered the rolled or planished finish.

For each material the three coefficients of friction corresponding to the three directions of movement were arranged in order of decreasing values of the coefficients of friction and grouped under each of the surface finishes considered. These data are shown in table 6.

The 14 groups of tests covering the 3 planed finishes and the milled finish were considered as a unit, the rolled or planished finish being considered alone.

For the 14 groups of tests, summations were then made of the total number of times each of the three directions of movement occurred in the high, intermediate, and low-value groups of the coefficient of friction for each combination of material and each surface finish shown in table 6. These totals were then converted into percentages of the total number of groups of tests, which resulted in the relations between the three directions of movement shown in table 7.

TABLE 6.—*Effect of direction of movement on the magnitude of the coefficient of friction, for like metals in combination, unlubricated*

Materials used	Coarse-planed finish		Medium-planed finish		Fine-planed finish		Milled finish		Rolled or planished finish	
	Direction of movement	Coefficient of friction (k)	Direction of movement	Coefficient of friction (k)	Direction of movement	Coefficient of friction (k)	Direction of movement	Coefficient of friction (k)	Direction of movement	Coefficient of friction (k)
Bronze A	M_2	[1] 0.390	M_2	[1] 0.161	M_3	[1] 0.154	M_2	0.162	M_2	[1] 0.164
	M_1	.157	M_3	.151	M_1	.152	M_3	[1] .154	M_1	.157
	M_3	.150	M_1	.138	M_2	.143	M_1	.148	M_3	[1] .146
Bronze D	M_2	[1] .448	M_2	[1] .172	M_1	[1] .210	M_2	.146	M_3	[1] .194
	M_1	.163	M_3	.166	M_3	[1] .204	M_3	.146	M_1	.172
	M_3	.158	M_1	.152	M_2	[1] .190	M_1	.140	M_2	[1] .168
Rolled steel	M_2	[1] .456	------	------	M_1	[1] .266	M_1	[1] .215	------	------
	M_1	[1] .224	------	------	M_2	[1] .243	M_2	[1] .176	------	------
	M_3	[1] .211	------	------	M_3	[1] .220	M_3	[1] .174	------	------
Cast steel	M_2	[1] .392	------	------	M_1	[1] .218	M_1	[1] .186	------	------
	M_3	[1] .190	------	------	M_2	[1] .198	M_3	[1] .162	------	------
	M_1	[1] .174	------	------	M_3	[1] .187	M_2	[1] .150	------	------

[1] Seizure occurred.

Symbols used are:
M_1 = Direction of movement and finish of plates parallel.
M_2 = Direction of finish of plates parallel, direction of movement normal to direction of finish.
M_3 = Direction of finish of plates at right angles.

It will be seen that 93 percent of the tests in which movement M_3 was used fall within the groups of low and intermediate values of the coefficient of friction, while 79 percent of the tests in which movement M_2 was used fall within the groups of high and intermediate values of the coefficient of friction. Those tests in which movement M_1 was used are equally divided between the groups of low and intermediate and high and intermediate values of the coefficient of friction, being 64 percent in both cases.

TABLE 7.—*Classification of values of coefficient of friction for the various directions of movement*

Values of coefficient of friction (k)	Percentage of tests using each direction of movement		
	M_2	M_1	M_3
	Percent	*Percent*	*Percent*
High	57	36	7
Intermediate	22	28	50
Low	21	36	43

Symbols used are:
M_1 = Direction of movement and finish of plates parallel.
M_2 = Direction of finish of plates parallel, direction of movement normal to direction of finish.
M_3 = Direction of finish of plates at right angles.

In the same 14 groups of tests seizure was noted as follows: For movement M_2, 11 groups or 79 percent seized; for movement M_3, 9 groups or 64 percent seized; for movement M_1, 7 groups or 50 percent seized. The combinations of like ferrous materials seized in all tests while the combinations of like bronzes seized in only 9 out of 24 tests or in 38 percent.

If the bronze and ferrous materials are considered separately, table 6 gives the following indications for bronzes:

For finish P_C movement M_3 is best and movement M_1 ranks second.

For finish P_M movement M_1 is best with movement M_3 ranking second.

For finish P_F movement M_2 is best with movements M_1 and M_3 rating equally for second place.

For finish M movement M_1 is best with movement M_3 second, with but slight differences between the two.

This tabulation shows, as has already been concluded from table 5, that for bronzes in combination the milled or medium-planed finishes give the lowest coefficients of friction. For these finishes, direction of movement M_1 is most satisfactory, although in general there is not a great difference between the coefficients for M_1 and M_3.

For ferrous materials, table 6 indicates that, considering all finishes, direction of movement M_3 is superior to M_1 and M_2, since it gives the lowest values in 4 out of 6 groups. However, in the case of the milled finish, the difference between M_3 and M_2 is not significant.

It is apparent from table 6 that, in the two groups of tests with rolled or planished finishes, direction of movement had no pronounced effect, as both high and low values of the coefficients of friction were evenly divided between movements M_2 and M_3 and seizure was noted in both the high and low groups. No seizure was noted for movement M_1.

If one finish and one direction of movement were to be selected for all combinations of metals, the one that would probably be most generally satisfactory would be the milled finish with the finishing cuts at right angles (M_3).

COMBINATIONS OF LIKE OR UNLIKE FERROUS MATERIALS HAD HIGHEST COEFFICIENTS OF FRICTION

In the 190 tests made, only 31 (exclusive of 2 tests with rusted cast iron) showed evidence of wear, the loss in thickness varying from 0.0005 to 0.0020 of an inch. Of the 31 tests showing wear, 22 were of like materials (10 bronzes and 12 ferrous materials) and 9 were of unlike materials (4 bronzes in combination with ferrous materials and 5 combinations of unlike ferrous

TABLE 8.—*Effect of materials on the magnitude of the coefficient of friction (111 unlubricated sets considered)*

Combination of materials used	Number of sets tested	Group no. 1—37 lowest values of k [1]				Group no. 2—37 intermediate values of k				Group no. 3—37 highest values of k			
		Number of sets	Percentage of sets tested	Number of sets showing seizure	Number of sets showing wear	Number of sets	Percentage of sets tested	Number of sets showing seizure	Number of sets showing wear	Number of sets	Percentage of sets tested	Number of sets showing seizure	Number of sets showing wear
Bronze and ferrous	22	18	81.8		3	3	13.6		1	1	4.6		
Unlike bronzes	7	5	71.4			2	28.6						
Like bronzes	47	14	29.8	2	2	25	53.2	8	4	8	17.0	8	1
Unlike ferrous	13					2	15.4	2		11	84.6	10	4
Like ferrous	22					5	12.7	5	1	17	77.3	17	6
Total	111	37		2	5	37		15	6	37		35	11

[1] k = Coefficient of friction.

materials); 9 were lubricated and 22 were unlubricated. Twenty seized during testing and 11 did not seize.

In 20 cases wear was evident where a coarse-planed finish (P_C) was used, in 3 cases where a medium-planed finish (P_M) was used, in 5 cases where a fine-planed finish (P_F) was used, and in 3 cases where a milled finish (M) was used.

Wear occurred in 20 cases where the direction of movement and the directions of finish of both plates were parallel (M_1), in 6 cases where the directions of finish were parallel and the direction of movement was normal thereto (M_2), and in 5 cases where the directions of finish of the plates were at right angles (M_3).

Seventeen of the combinations showing wear consisted of ferrous materials, 10 combinations consisted of bronzes, and 4 combinations consisted of bronze and ferrous materials. In three cases, where unequal wear occurred in the two plates of a combination of bronze and ferrous metal, the ferrous materials showed the greater wear.

In reaching any conclusion with respect to the importance of wear as disclosed by these tests, consideration should be given to the fact that the wear observed took place during only 1,200 slips of the test plates and that this number of movements represents only a very limited part of the total number to which bearing plates may be subjected during their useful life. Measurable wear occurred in only a small percentage of the total number of tests, and in the majority of the cases where it did occur, either a coarse-planed finish, which would not be recommended in any case, or a finish or direction of movement unsuited to the particular combinations of metals involved was used. Therefore, it seems probable that when a proper selection of materials and surface finishes is made, wear may be expected to be negligible.

Since the use of a lubricant appeared to be of doubtful value in permanently decreasing the coefficients for given materials, and furthermore, since tests of lubricated combinations were not made in all cases, only the 111 tests of unlubricated plates listed in table 3 (tests of rusted plates excluded) were considered in determining the relative merits of the materials tested for use in bridge bearing plates.

By arranging these 111 tests in the order of increasing coefficients of friction and dividing them into three groups of 37 tests each, the results shown in table 8 were obtained. These clearly indicate that combinations of bronze and ferrous materials and of unlike bronzes in combination are the most efficient, as 18 out of a total of 22, or 82 percent, and 5 out of 7, or 71 percent, respectively, of the total number of tests made of these two classes of combinations fall within the group having the lowest coefficients of friction (group 1, table 8). Moreover, these two classes of combinations comprise 23 out of a total of 37, or 62 percent of the total tests falling in group 1.

In group 1, seizure was noted in only two combinations and was small in amount. These were like bronzes, both with a rolled finish, and seizure occurred in only 7 and 12 percent, respectively, of the total number of slips under any load intensity.

Group 3 of table 8 indicates that the combinations of unlike or of like ferrous materials are the most unsatisfactory of all of those tested, as 11 out of 13, or 85 percent, and 17 out of 22, or 77 percent, respectively, of the total number of tests made of these combinations fall within the group of the highest values of the coefficient of friction. These two classes of combinations comprise 28 out of 37, or 76 percent, of the tests falling within this group. Seizure was noted in all of the tests made of these two classes of combinations with the single exception of one combination of unlike ferrous materials.

It will be noted by reference to the general compilation of results (table 3) that the high lead bronzes in combination with like materials, or in combination with phosphor bronze or stainless steel, rank among the most satisfactory. The high lead bronze in combination with stainless steel shows next to the lowest coefficient of friction (0.110) of the 111 unlubricated combinations tested. The high lead bronzes in combination with like materials or in combination with phosphor bronze fall within the 13 lowest coefficients of friction of the 111 unlubricated combinations tested, with coefficients ranging from 0.128 to 0.132 as compared to the mean coefficient, 0.137, of group 1, table 3. This group comprises the 37 lowest coefficients of the 111 tests made of unlubricated plates.

EXPOSURE TO CALCIUM CHLORIDE HAD LITTLE EFFECT ON PLATES

Since the tests in this investigation indicated that combinations of ferrous materials and bronzes produced the lowest coefficients of friction and also indicated that rust may result in a substantial increase in the coefficient of friction, the use of stainless steel suggested itself because of its nonrusting properties. However, doubt existed as to the possible electrolytic action which might result from its use in combination with bronze when exposed to salt air. For the above reasons, a limited series of exposure tests was made in an attempt to obtain indications of electroytic action, if such existed.

The procedure adopted was as follows: Eight samples of cast bronze, four of grade A and four of grade B,

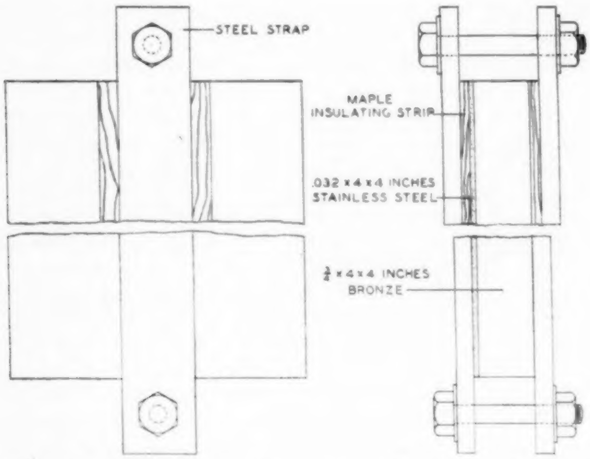

FIGURE 8.—ASSEMBLY OF PLATES FOR TESTS TO DETERMINE ELECTROLYTIC ACTION.

with machined surfaces, were used in combination with thin plates of stainless steel 0.032 inch thick with cold-rolled surfaces as furnished by the manufacturer. These eight combinations of bronze and steel were clamped together by means of straps of iron or soft steel 1 inch wide bolted around the centers of the 4-inch square specimens used. In four sets of specimens the clamps were in direct contact with the specimens, thus forming a direct metallic or uninsulated bond between the two plates. In the other four sets of specimens thin strips of maple were placed between the clamps and specimens as insulation. The methods of clamping the specimens together and of insulating them are shown in figure 8.

One insulated and one uninsulated set of specimens were subjected to calcium chloride vapor by suspending them in the top of a brine tank of a cold storage plant. One insulated and one uninsulated set of specimens were subjected to a vapor of sodium chloride by suspending them over a saturated solution of this salt through which a small amount of air was continually passing, the top of the container being covered with canvas.

One set each of insulated and uninsulated specimens were immersed in saturated solutions both of calcium chloride and of sodium chloride. All specimens were left in place for 4 months. They were then removed, rinsed in hot water and dried with paper towels. All of the specimens were measured with micrometer calipers before and after exposure.

The four specimens exposed to calcium chloride either in vapor or immersed in the solution will be considered first (figs. 9 and 10). In no case was any apparent effect of exposure present on the contact faces of either the stainless steel or the bronzes. The outer face of the stainless steel immersed with no insulation between the specimens and the iron clamps showed a slight deposit of copper except where covered with the clamps. None of the other three stainless steel specimens showed any effect on the outer faces. Three of the four bronze specimens showed discoloration of the outer surfaces except where the surfaces were covered with either the clamps or the insulation strips. In no case was there any apparent breaking down of the surface or any measurable change in thickness of either the bronze or steel specimens.

EXPOSURE TO SODIUM CHLORIDE NOT DETRIMENTAL TO PLATES

In the case of the four specimens exposed to sodium chloride vapor or immersed in the solution, the following effects were noted (figs. 11 and 12).

The two steel specimens that were immersed showed no effect of immersion on the contact faces. The contact face of one bronze specimen showed no effect of immersion, while the other bronze specimen showed one small discolored spot where the contact between the steel and bronze was poor. One of the outer faces of the steel specimens showed no effect of immersion, while the other specimen was discolored in spots where salt crystals had formed. The outer faces of both bronze specimens were slightly discolored by immersion except where the surface was covered by the clamps or insulation strips.

The contact faces of both the two steel specimens and the two bronze specimens that were exposed to vapor showed discoloration in spots where contact between the steel and the bronze was poor. Both sets of specimens showed two bright spots on both the steel and the bronze where the contact between the bearing faces was good. The outer face of one steel specimen was discolored where it was in contact with the black iron clamps, while the other was discolored in two spots adjacent to the clamps. The outer faces of both bronze specimens exposed to vapor were discolored and one specimen showed two spots of corrosion adjacent to the iron clamps with a resulting increase in roughness of the surface.

No measurable change in thickness was found in any of the specimens and in only the one bronze specimen where corrosion was found was any apparent break-down of the surface noted. Figures 9 to 12 show both contact and outer faces after the exposure tests were completed. Differences in texture, color, and surface finish, with the resulting variations in the reflection of light, presented a difficult problem to the photographer. As a result, these photographs may give an exaggerated idea of the conditions of the various surfaces. However, they give a fair idea of the relative results of the various exposures.

Examination of these plates for evidences of electrolytic action revealed that only one of the eight sets of specimens gave indications of such action. When bronze A, in combination with stainless steel, was immersed in a solution of calcium chloride with no insulation between the iron clamps and the test specimens (i. e., with a direct metallic connection between the unlike materials), a deposit of copper was found on the outer surface of the steel except where it was covered by the clamp (fig. 9, no. 7). The outer surface of the bronze also showed an increase of copper on the surface

In none of the eight sets of specimens were effects of electrolysis evident on the contact faces of the specimens although in three of the bronze specimens and two of the steel specimens these faces were discolored in spots where contact between the two surfaces was imperfect. Due consideration should be given to the fact that the stainless steel plates used in these tests were only 0.032 inch thick and consequently were

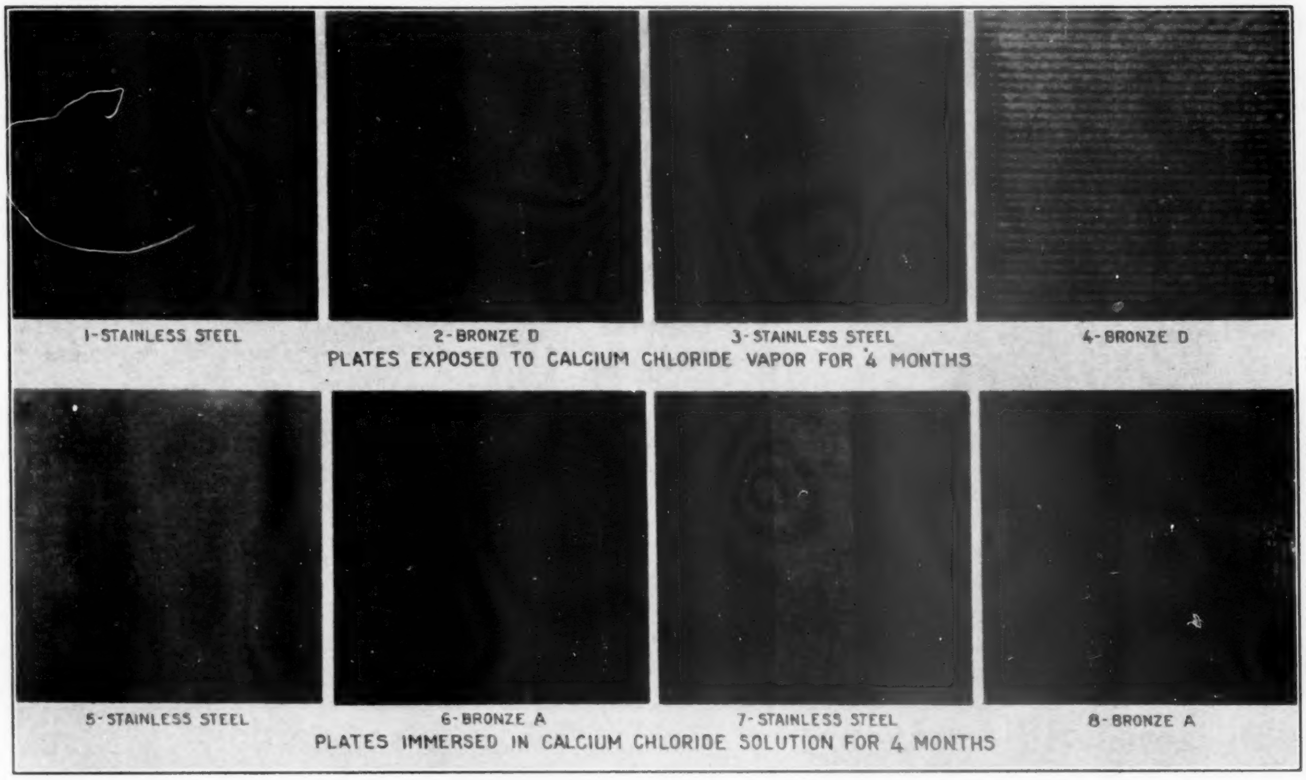

FIGURE 9.—APPEARANCE OF BRONZE AND STAINLESS STEEL BEARING PLATES AFTER IMMERSION IN AND EXPOSURE TO CALCIUM CHLORIDE. THERE WAS NO INSULATION BETWEEN CLAMPS AND PLATES. NOS. 1, 2, 5, AND 6 WERE CONTACT FACES, AND NOS. 3, 4, 7, AND 8 WERE OUTER FACES OF PLATES.

FIGURE 10.—APPEARANCES OF BRONZE AND STAINLESS STEEL BEARING PLATES AFTER IMMERSION IN AND EXPOSURE TO CALCIUM CHLORIDE. STRIPS OF WOOD INSULATED THE IRON CLAMPS FROM THE PLATES. NOS. 1, 2, 5, AND 6 WERE CONTACT FACES, AND NOS. 3, 4, 7, AND 8 WERE OUTER FACES OF PLATES.

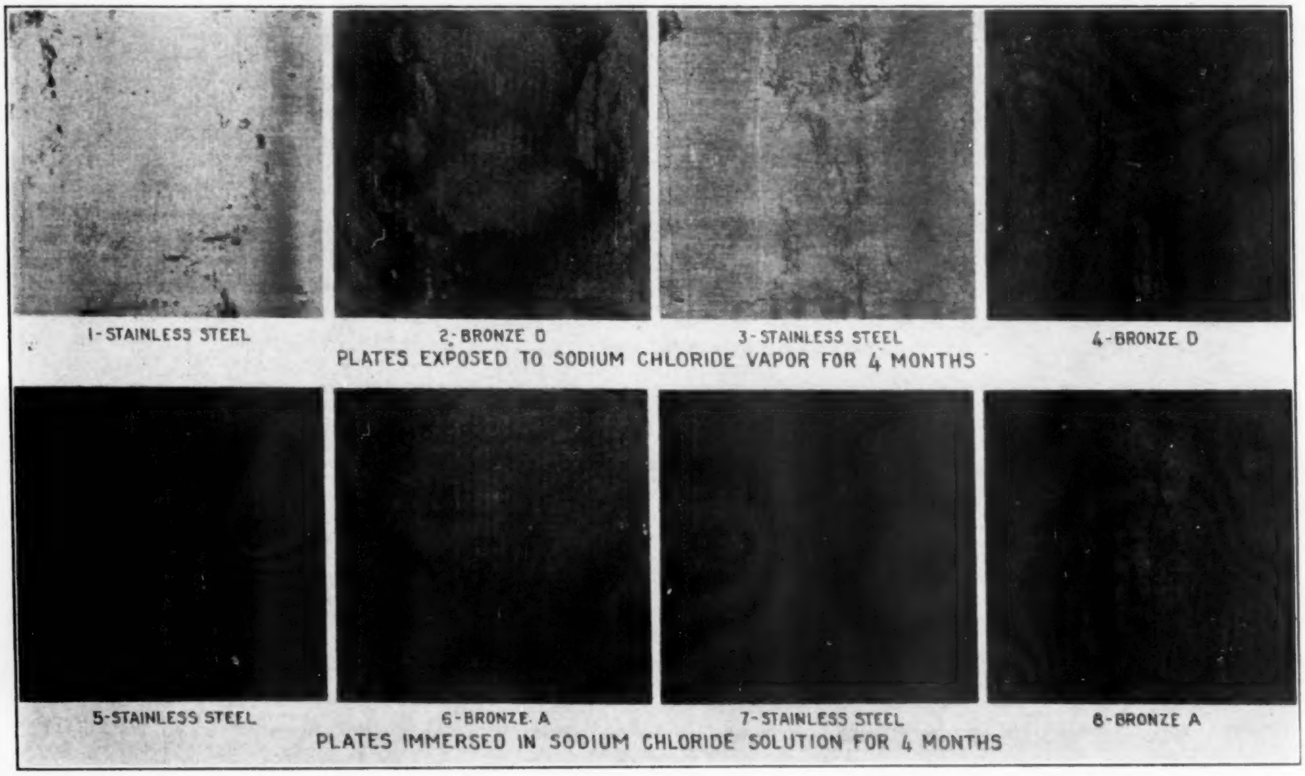

FIGURE 11.—APPEARANCES OF BRONZE AND STAINLESS STEEL BEARING PLATES AFTER IMMERSION IN AND EXPOSURE TO SODIUM CHLORIDE. THERE WAS NO INSULATION BETWEEN CLAMPS AND PLATES. NOS. 1, 2, 5, AND 6 WERE CONTACT FACES, AND NOS. 3, 4, 7, AND 8 WERE OUTER FACES OF PLATES.

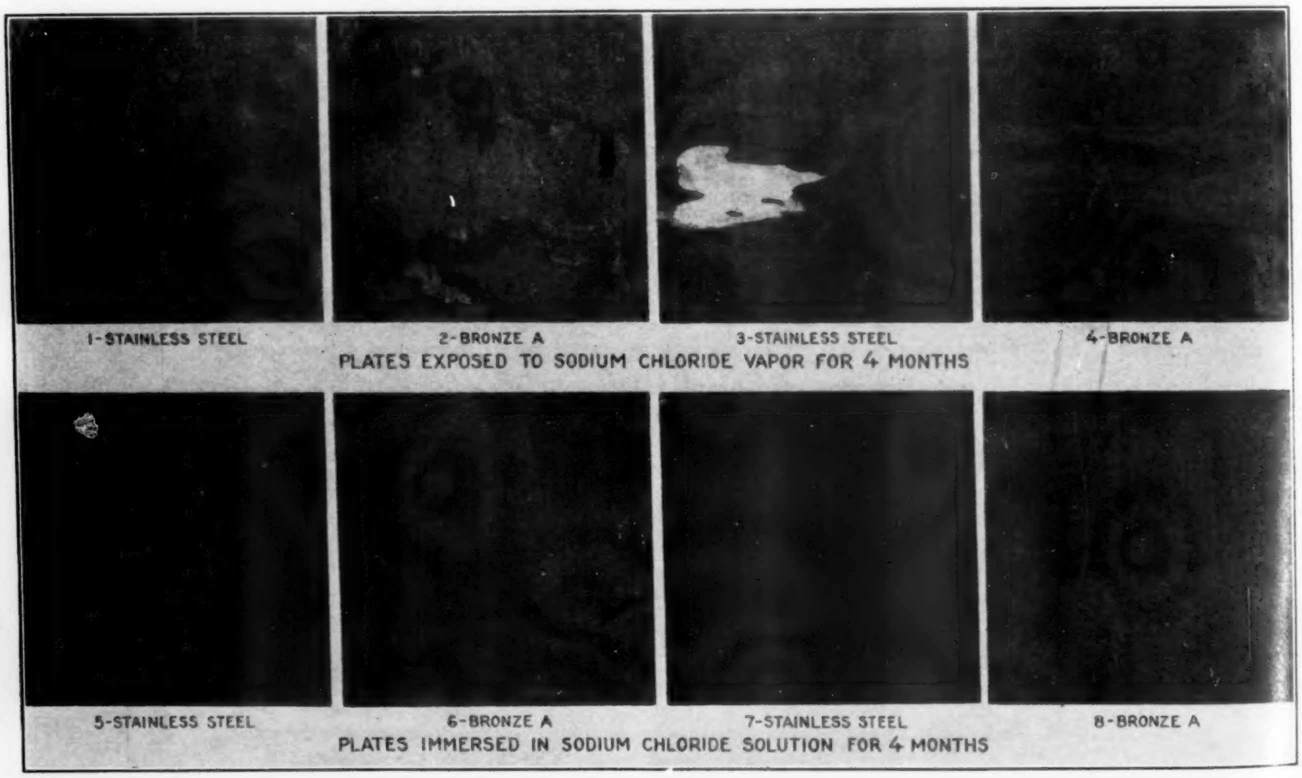

FIGURE 12.—APPEARANCES OF BRONZE AND STAINLESS STEEL BEARING PLATES AFTER IMMERSION IN AND EXPOSURE TO SODIUM CHLORIDE. STRIPS OF WOOD INSULATED THE IRON CLAMPS FROM THE PLATES. NOS. 1, 2, 5, AND 6 WERE CONTACT FACES, AND NOS. 3, 4, 7, AND 8 WERE OUTER FACES OF PLATES.

somewhat flexible. Moreover, they were clamped to the bronze specimens by clamps only 1 inch in width passing over the center of the specimens. As a result any slight unevenness, caused by shearing of the thin-steel plates or by marking with an identification number, caused faulty contact between the plates and allowed vapor or moisture to penetrate and settle. It is believed that, where thicker plates are used and are subjected to pressures usually existing on bridge bearing plates, contact between the surfaces will be such as to prevent penetration by either moisture or vapor. Four of the eight outer surfaces of the steel showed no effect, one showed the copper deposit mentioned above, and three were discolored in spots adjacent to the clamps undoubtedly resulting from the breaking down of the black iron of the clamps. No evidence of any break-down of the surface was apparent.

The outer surfaces of the bronze specimens showed the normal discoloration to be expected when finished metal is exposed to salt air, and in one specimen two small spots of corrosion with a slight increase in roughness were found adjacent to the iron clamps. The iron clamps all showed pitted and rusted surfaces as a result of exposure.

These tests would seem to indicate that for normal exposure to salt air no electrolytic action or breaking down of contact faces may be expected when bronze and stainless steel are used in combination if the contact between the plates is good.

CONCLUSIONS

1. The coefficient of friction for bearing plates remains constant under varying loads for any combination of materials tested.

2. An initial application of graphite grease or other lubricant that will flow appears to be of doubtful value in permanently reducing the coefficients of friction when used under conditions such as obtained in these tests.

3. In general, for the materials tested the relative coefficients of friction, in increasing order of magnitude, are as follows:

a. Ferrous materials in combination with bronzes.
b. Hard bronzes in combination with softer bronzes.
c. Like bronzes in combination.
d. Ferrous materials in combination with like or unlike ferrous materials.
e. Ferrous materials in combination where subject to rust.

4. The following are indicated as the most satisfactory finishes for various combinations of materials:

a. Ferrous materials in combination—a milled finish.
b. Like bronzes in combination—a milled or medium-planed finish.
c. Ferrous materials and bronzes in combination—a milled or fine-planed surface.
d. A cold-rolled finish on bronze compares favorably with machined finishes provided the plates are rolled to a surface which will give uniform contact.

5. The directions of movement most satisfactory for machined plates are with finishing cuts at right angles (M_3) and with direction of movement and direction of finishing cuts parallel (M_1), with M_3 showing a slight superiority. With rolled or planished finishes, but slight variations in friction are caused by the direction of movement, although less seizure is noted when the direction of movement and the direction of finish are parallel.

6. Wear is probably a negligible factor when suitable materials and finishes are used.

7. The limited exposure tests made do not indicate that destructive corrosive action may be expected from the use of combinations of bronze and stainless steel when exposed to salt air.

8. If proper care is used in selecting materials and finishes, a coefficient of friction varying from 0.10 to 0.15 may be expected, with variations of 5 percent above and below mean values, for load intensities of the order of 250 to 1,000 pounds per square inch.

DISPOSITION OF STATE MOTOR-

[Compiled from reports

State	Net total receipts of calendar year	Adjustments due to undistributed balances, etc.[1]	Net total funds distributed[2]	Expenses of collection and administration	For other administrative purposes[3]	For State highway purposes: Construction, maintenance, and administration[4]	For State highway purposes: State highway police	Service of State highway obligations: State highway bonds	Service of State highway obligations: State-assumed local obligations[5]	Service of State highway obligations: Notes and other short-term loans	Service of State highway obligations: Total	Total for State highway purposes
Alabama	$10,313,112	−$3,068	$10,310,044	$29,298	$43,691	$3,735,071	$39,300	$1,355,498			$1,355,498	$5,129,869
Arizona	3,278,598		3,278,598	39,946		1,981,576	82,938					2,064,514
Arkansas	8,261,907	−15,798	8,246,109	304,457	68,118	1,400,390		2,748,773	$3,059,506	$70,396	5,878,675	7,279,065
California	39,983,955	−2,365,667	37,618,288	132,687		24,793,382						24,793,382
Colorado	6,009,533	−439	6,009,094	98,134		4,243,132	73,128					4,316,260
Connecticut	5,671,844	−159,224	5,512,620	41,000		5,471,620						5,471,620
Delaware	1,481,819	[11] 228,563	1,710,382	6,076		1,049,105	96,621	52,748	277,269		330,017	1,475,743
Florida	17,896,972	−10,813	17,886,159	20,427		7,581,351	58,957		2,552,247		2,552,247	10,192,555
Georgia	15,771,723		15,771,723	472,181		7,496,569						7,496,569
Idaho	3,124,297	−5,325	3,118,972	10,292		2,901,555		207,125			207,125	3,108,680
Illinois	30,385,382	28,714	30,414,096	142,507	178,002	9,566,502						9,566,502
Indiana	19,262,319		19,262,319	81,657	67,056	9,391,090						9,391,090
Iowa	11,549,118	5,000	11,554,118	92,118		3,060,253			3,309,747		3,309,747	6,370,000
Kansas	8,961,190	33,289	8,994,479	295,766	86,500	5,356,573	66,618		693,266		693,266	6,116,457
Kentucky	9,835,918	31,398	9,867,316	48,507		9,794,488	24,321					9,818,809
Louisiana	9,416,969	578,665	9,995,634	62,000				8,064,450			8,064,450	8,064,450
Maine	4,572,827	−1,058	4,571,769	14,872		2,611,947	148,448	1,253,086			1,253,086	4,013,481
Maryland	8,278,025		8,278,025	51,331		2,976,166		1,380,548			1,380,548	4,356,714
Massachusetts	17,334,090	2,824	17,336,914	50,000		3,764,015	200,792	441,930		15,445	457,375	4,422,182
Michigan	22,790,561	−23,476	22,767,085	120,945		12,465,565		4,082,060			4,082,060	16,547,625
Minnesota	11,362,258	−35,584	11,326,674	166,696		7,267,351	127,937					7,395,288
Mississippi	7,512,370	−3,242	7,509,128	26,858	70,000	4,268,447	26,349					4,294,796
Missouri	9,845,301	64,699	9,910,000	49,571	105,585	5,470,283	139,189	4,145,372			4,145,372	9,754,844
Montana	3,844,542	78,764	3,923,306	18,631		3,100,035		804,640			804,640	3,904,675
Nebraska	9,808,734	−7,028	9,801,706	95,514		5,370,609						5,370,609
Nevada	962,040		962,040	1,950		928,972	16,846		14,272		14,272	960,090
New Hampshire	2,868,166	4,360	2,872,526	4,150		1,970,753		726,895			726,895	2,697,648
New Jersey	18,205,102	[18] −1,387,702	16,817,400	84,959		475,764		7,597,651			7,597,651	8,073,415
New Mexico	2,877,605		2,877,605	62,325		1,301,584		1,513,696			1,513,696	2,815,280
New York [20]	56,311,245	166,865	56,478,110	92,714		5,024,734	483,436	3,675,900			3,675,900	9,184,070
North Carolina	19,147,015	17,533	19,164,548	6,199	24,995	5,760,418	179,618	6,602,269	399,196		7,001,465	12,941,501
North Dakota	2,323,387	−2,611	2,320,776	25,000		1,523,041	6,959					1,530,000
Ohio	39,169,151	−1,354,539	37,814,612	183,446		15,654,932	354,386					16,009,318
Oklahoma	11,877,151	−324,787	11,552,364	237,543		4,911,832						4,911,832
Oregon	7,942,853	−99,525	7,843,328	26,129		3,649,210	198,473	2,805,233			2,805,233	6,652,916
Pennsylvania	[25] 40,651,831	[26] 493,817	41,145,648	209,677		22,723,714	793,531	3,322,949			3,322,949	26,840,194
Rhode Island	2,106,204	58,359	2,164,563	16,973		1,544,353		301,876			301,876	1,846,229
South Carolina	[28] 8,765,749	−66,777	8,698,972	[29] 38,500	[29] 9,500	3,522,026		1,117,962	2,524,151	544	3,642,657	7,164,683
South Dakota	4,315,419	24,079	4,339,498	44,410		1,877,967						1,877,967
Tennessee	14,966,016	234,778	15,200,794	150,594		2,103,571		50,356	2,133,833	4,095,377	6,279,566	8,383,137
Texas	33,606,085	−86,806	33,519,279	335,345		16,603,812			8,290,061		8,290,061	24,893,873
Utah	2,714,341	−29,341	2,685,000	8,000		2,577,183	99,817					2,677,000
Vermont	2,048,645	219,677	2,268,322	2,200		1,218,366	34,560	447,445			447,445	1,700,371
Virginia	13,340,505	−147,169	13,193,336	164,160	28,885	6,351,567		476,210			476,210	6,827,777
Washington	12,568,379		12,568,379	22,684		4,036,904		[34] 97,930			97,930	4,134,834
West Virginia	6,102,941	−1,741	6,101,200	23,468		1,603,058		4,233,429			4,233,429	5,836,487
Wisconsin	16,249,747	−825,947	15,423,800	52,421	178,540	6,286,279			2,277,229		2,277,229	8,563,508
Wyoming	1,931,912	90,403	2,022,315	11,051		1,269,578	32,479	112,000			112,000	1,414,057
District of Columbia	2,197,209	374,793	2,572,002	([30])								
Total [37]	619,802,062	−4,221,087	615,580,975	4,275,369	860,872	258,036,693	3,284,703	57,618,031	25,530,777	4,181,762	87,330,570	348,651,966

[1] Amounts distributed during the calendar year differ in many cases from actual collections because of undistributed balances and lag between accounts of collecting and expending agencies. Adjustments also include deduction of receipts not classed as highway-user imposts as follows: Proceeds of tax on gasoline used in aviation in Idaho, Maine, Michigan, Nebraska, Oregon, and Wyoming, and proceeds of tax on nonmotor-vehicle fuel in Ohio.

[2] In many States the proceeds of motor-fuel taxes, motor-vehicle fees, and motor-carrier taxes are placed in a common fund from which the distribution is made. In these cases the amounts distributed have been prorated in proportion to the receipts, not otherwise dedicated, from these three sources of revenue. See following tables.

[3] Where reported separately from collection expenses, funds allotted for motor-fuel inspection, administration of motor-vehicle department, and regulation of motor vehicles are shown in this column.

[4] Includes funds allotted for expenditure on urban extensions of State highway system, where reported separately from other funds distributed for local roads and streets.

[5] County or local obligations assumed by State as reimbursement for local roads added to State system.

[6] In States indicated by star (*) law provides that allotments for work on local roads or streets may also be used for service of local highway obligations, but amounts so used not reported separately.

[7] In a number of States allotments for local road work may be used on city streets. This column shows allotments which were reported separately. See note 4.

[8] To State general funds unless otherwise noted. Allocations to county or municipal general funds may have been used in part for highways, but such amounts not reported.

[9] For engineering expenses in connection with irrigation.

[10] Funds allotted to counties for use on both State and local roads.

[11] Pro-rata share of State highway sinking fund transferred to general fund as a result of refunding operation which replaced sinking fund bonds with serial bonds.

[12] To Division of Airways, $15,616; Dade Memorial Park, $818.

[13] For Confederate pensions and past-due teachers' salaries, $1,786,840; prison camps, $2,968.

[14] To ports of New Orleans and Lake Charles Harbor for harbor improvement.

[15] To Conservation Department for oyster propagation, $75,000; Chesapeake Bay ferry companies, $48,727.

[16] Pro-rata share (approximate) of debt service on nonhighway portion of emergency public works loan.

FUEL TAX RECEIPTS, 1935

of State authorities]

For local roads and streets [6]				For other highway purposes (park and forest roads, etc.)	For nonhighway purposes					State
For work on county and local roads	For work on city streets [7]	Service of local highway obligations	Total		To general funds [8]	For relief of unemployment or destitution	For education	For other purposes	Total	
$5,107,186			$5,107,186							Alabama.
*983,365			983,365			$186,667		[9] $4,106	$190,773	Arizona.
512,731		$81,738	594,469							Arkansas.
*12,510,058	$182,161		12,692,219							California.
[10] 1,594,700			1,594,700							Colorado.
										Connecticut.
					[11] $228,563				228,563	Delaware.
		5,104,495	5,104,495		2,552,248			[12] 16,434	2,568,682	Florida.
2,537,013			2,537,013		860,675		$2,615,477	[13] 1,789,808	5,265,960	Georgia.
										Idaho.
*6,569,243	*6,596,832		13,166,075		144,269	3,512,788	3,703,953		7,361,010	Illinois.
7,512,872	1,878,218		9,391,090		331,426				331,426	Indiana.
*5,092,000			5,092,000							Iowa.
2,495,756			2,495,756							Kansas.
										Kentucky.
							934,592	[14] 934,592	1,869,184	Louisiana.
543,416			543,416							Maine.
779,019	2,312,168	642,106	3,733,293		12,960			[15] 123,727	136,687	Maryland.
2,372,739			2,372,739	$538,204	9,500,000	[16] 453,789			9,953,789	Massachusetts.
*6,094,185			6,094,185		4,330				4,330	Michigan.
*3,697,644			3,697,644		67,046				67,046	Minnesota.
*3,117,474			3,117,474							Mississippi.
										Missouri.
										Montana.
*2,901,185	321,180		3,222,365			1,113,218			1,113,218	Nebraska.
										Nevada.
		[17] 170,728	170,728							New Hampshire.
2,765,678		192,763	2,958,441			3,964,062	1,332,500	[19] 404,023	5,700,585	New Jersey.
										New Mexico.
*8,090,771			8,090,771		[21] 39,110,555				39,110,555	New York.[20]
[22] 4,712,527			4,712,527		1,479,326				1,479,326	North Carolina.
765,000			765,000		776				776	North Dakota.
7,205,400	[23] 4,929,445		12,134,845				9,487,003		9,487,003	Ohio.
*2,908,983			2,908,983		3,228			[24] 3,490,778	3,494,006	Oklahoma.
*1,144,003			1,144,003	20,280						Oregon.
*8,345,374	579,361		8,924,735	46,567		5,086,269		[27] 38,206	5,124,475	Pennsylvania.
						301,361			301,361	Rhode Island.
*1,352,684			1,352,684		[29] 133,605				133,605	South Carolina.
				60,520	114,425			[30] 2,242,176	2,356,601	South Dakota.
4,232,978			4,232,978			104,821		[31] 2,329,264	2,434,085	Tennessee.
							8,290,061		8,290,061	Texas.
										Utah.
565,751			565,751							Vermont.
[32] 6,170,790			6,170,790					[33] 1,724	1,724	Virginia.
*6,511,680	994,320	[34] 79,574	7,585,574			[34] 825,287			825,287	Washington.
[22] 241,245			241,245							West Virginia.
3,389,383	489,436		3,878,819	109,614	[35] 2,640,898				2,640,898	Wisconsin.
597,207			597,207							Wyoming.
	2,572,002		2,572,002							District of Columbia.
123,420,040	20,855,123	6,271,404	150,546,567	775,185	57,184,330	15,548,262	26,363,586	11,374,838	110,471,016	Total.[37]

[17] Pro-rata share service of highway relief bonds, a State obligation incurred for improvement of local roads.
[18] Includes $767,240, pro-rata share of temporary loan to general fund for relief.
[19] For service of institutional construction bonds, $434,468; Department of Commerce and Navigation, $90,000; less credit for excess allocations in 1934, (—) $120,445.
[20] Appropriations out of general fund for highway purposes have been credited against payments of motor-fuel tax and motor-vehicle fees to the State general fund and prorated in proportion to net receipts not otherwise dedicated.
[21] To State general fund after crediting appropriations for highway purposes, $37,614,987; New York City general fund, $1,495,568.
[22] For county roads under State control.
[23] In cities situated on State highways one-sixth municipal allotment to be used on urban extensions of State system.
[24] For service of general State debt.
[25] Differs from total in a previous table issued by the Bureau—State motor-fuel tax receipts, 1935—by amount of refunds, $57,009, reported subsequent to issuance of previous table.
[26] In computing adjustment, amounts loaned to general fund for relief purposes in 1934 and 1935 (pro-rata share, $3,622,384) have been included in the undistributed balances.
[27] For aircraft landing fields, $25,824; cooperative work other departments, $12,382.
[28] Differs from total in a previous table issued by the Bureau—State motor-fuel tax receipts, 1935—by amount of inspection fees, $181,605, reported subsequent to issuance of previous table.
[29] Amount shown as payment to general fund represents proceeds of inspection fees paid to general revenue, $181,605, less estimated cost of tax collection and inspection, as given above.
[30] For payments on real-estate bonds.
[31] Service of general fund bonds, $2,116,489; Great Smoky Mountain Park bonds, $211,649; aviation projects, $1,126.
[32] For county roads under State control in all but 3 counties, $5,944,322; transferred to remaining 3 counties, $226,468.
[33] For aviation purposes.
[34] Debt service charges on $10,000,000 emergency relief bond issue prorated in proportion to allotments for State highways, local roads, and nonhighway purposes.
[35] Includes $500,000 to State general fund and $2,140,898 to towns, cities, and villages in lieu of personal property tax formerly imposed on motor vehicles.
[36] Paid out of general revenue. Amount not reported.
[37] See notes 25 and 28.

DISPOSITION OF STATE MOTOR-

[Compiled from reports

State	Net total receipts of calendar year [1]	Adjustments due to undistributed balances, etc.[2]	Net total funds distributed [3]	Expenses of collection and administration [4]	For other administrative purposes [5]	For State highway purposes: Construction, maintenance, and administration [6]	For State highway purposes: State highway police	For State highway purposes: Service of State highway obligations: State highway bonds	For State highway purposes: Service of State highway obligations: State-assumed local obligations [7]	For State highway purposes: Service of State highway obligations: Notes and other short-term loans	For State highway purposes: Service of State highway obligations: Total	For State highway purposes: Total for State highway purposes
Alabama	$3,574,151	−$1,096	$3,573,055	$349,048		$2,064,145	$133,664	$373,015			$373,015	$2,570,824
Arizona	848,146	−15,266	832,880	149,466		654,658	27,400					682,058
Arkansas	2,529,191		2,529,191	75,484		455,460	86,280	894,005	$995,067	$22,895	1,911,967	2,453,707
California	10,562,502	−613,724	9,948,778	2,028,889		2,931,082	2,068,763					4,999,845
Colorado	2,206,930		2,206,930	311,620	$36,067	72,245						72,245
Connecticut	6,108,224		6,108,224	853,699		2,754,987	325,000					3,079,987
Delaware	1,072,079	[14] 332,606	1,404,685	46,654		728,974	67,138	36,652	192,661		229,313	1,025,425
Florida	4,954,774		4,954,774	375,204	174,211							
Georgia	1,248,278		1,248,278	165,024	45,577	754,723						754,723
Idaho	1,880,085	−84,256	1,795,829	57,685		168,325	53,065					221,390
Illinois	20,437,737	318	20,438,055	941,341	304,279	7,508,748	893,175	9,081,120	376,789		9,457,909	17,859,832
Indiana	8,154,293	−53,893	8,100,400	839,447		3,182,090	385,227					3,567,317
Iowa	10,314,046	−313,374	10,000,672	752,862		4,442,800			4,805,010		4,805,010	9,247,810
Kansas	3,495,576	−16,027	3,479,549	255,706		1,994,335	25,159		261,815		261,815	2,281,309
Kentucky	3,491,413	−13,823	3,477,590	385,599	32,099	2,528,753	15,132					2,543,885
Louisiana	3,563,380	−11,66'	3,551,719	145,657		2,762,785	342,477	300,800			300,800	3,406,062
Maine	3,236,078	−1,366	3,234,712	104,556	12,836	1,786,802	101,552	857,221			857,221	2,745,575
Maryland	4,453,440	−259,198	4,194,242	246,726	38,403	1,543,461	260,699	1,140,598			1,140,598	2,944,758
Massachusetts	6,305,397		6,305,397	1,453,460	35,000	2,328,397	124,208	273,375		9,555	282,930	2,735,535
Michigan	17,601,108	133,288	17,734,396	1,177,833			250,000					250,000
Minnesota	7,215,403	250,274	7,465,677	417,663	361,246	2,469,424	43,472	2,122,000	1,962,820		4,084,820	6,597,716
Mississippi	1,740,856	459	1,741,315	89,309		181,307	1,157					182,464
Missouri	8,311,786		8,311,786	485,415		4,388,842	111,672	3,325,857			3,325,857	7,826,371
Montana	1,381,568	−37,729	1,343,839	90,967			72,540					72,540
Nebraska	1,999,405	8,154	2,007,559	77,421		575,191	12,500					587,691
Nevada	263,511	−17,496	246,015	22,163		153,548	2,742	67,562			67,562	223,852
New Hampshire	1,691,502	−4,150	1,687,352	102,943		1,327,734	136,700	4,953			4,953	1,469,387
New Jersey	16,623,763	[18] −4,616,491	12,007,272	1,109,227		2,848,883						2,848,883
New Mexico	1,117,579	−13,934	1,103,645	127,564		439,237						439,237
New York [20]	43,956,507	−280,983	43,675,524	2,345,572	98,071	6,919,284	665,714	5,061,880			5,061,880	12,646,878
North Carolina	6,636,748	632,900	7,269,648	322,043		2,177,914	67,910	2,496,203	150,929		2,647,132	4,892,956
North Dakota	1,422,695	−156,431	1,266,264	83,905	24,674	216,343	20,000					236,343
Ohio	21,535,578	127,825	21,663,403	1,321,331		4,815,160	109,002					4,924,162
Oklahoma	3,861,366	−43,073	3,818,293	287,156	256,016	1,284,205						1,284,205
Oregon	2,748,249	7,345	2,755,594	318,290		1,137,778	61,881	874,636			874,636	2,074,295
Pennsylvania	28,758,933	[17] −1,782,890	26,976,043	1,391,596		21,137,536	738,140	3,090,998			3,090,998	24,966,674
Rhode Island	2,900,462	−1,494	2,898,968	259,468		2,269,111						2,269,111
South Carolina	1,791,050	−12,381	1,778,669	171,748		736,191	149,265	221,424	499,933	108	721,465	1,606,921
South Dakota	1,371,026	3,991	1,375,017	71,618		264,765						264,765
Tennessee	3,432,317	−33,989	3,398,328	214,089		2,751,490	190,922	66,476		35,488	101,964	3,044,376
Texas	15,745,897	−485	15,745,412	895,557		4,732,671	308,041					5,040,712
Utah	1,070,647	−233,382	837,265	99,765				737,500			737,500	737,500
Vermont	1,377,241	1,208,084	2,585,325	44,491		1,366,064	38,749	501,686			501,686	1,906,499
Virginia	5,150,755	9,741	5,160,496	312,404		4,479,035	194,960	173,469			173,469	4,847,464
Washington	3,495,253		3,495,253	341,161		2,635,070	507,098					3,142,168
West Virginia	4,820,637		4,820,637	48,459		1,125,795	29,277	2,973,051			2,973,051	4,128,123
Wisconsin	10,897,032	−326,651	10,570,381	661,541	35,000	4,199,529			1,538,492		1,538,492	5,738,021
Wyoming	482,893	−9,414	473,479	9,470		287,351	10,658	166,000			166,000	464,009
District of Columbia	910,226		910,226	99,172	63,493							
Total	318,747,713	−6,239,672	312,508,041	22,537,468	1,516,972	113,582,228	8,631,339	34,840,481	10,783,516	68,046	45,692,043	167,905,610

1 Amounts for many States differ from totals in a previous table issued by the Bureau—State motor-vehicle receipts, 1935—which gives receipts of the 1935 registration period.

2 Amounts distributed during the calendar year differ in many cases from actual collections because of undistributed balances and lag between accounts of collecting and expending agencies.

3 In many States the proceeds of motor-fuel taxes, motor-vehicle fees, and motor-carrier taxes are placed in a common fund from which the distribution is made. In these cases the amounts distributed have been prorated in proportion to the receipts, not otherwise dedicated, from these three sources of revenue. See tables that precede and follow this table.

4 Collection expenses in many States include service charges deducted by county and local collectors.

5 Where reported separately from collection expenses, funds allotted for collection of motor-fuel tax, payments to auto theft fund, and miscellaneous expenses of motor-vehicle regulation are shown in this column.

6 Includes funds allotted for expenditure on urban extensions of State highway system, where reported separately from other funds distributed for local roads and streets.

7 County or local obligations assumed by State as reimbursement for local roads added to State system.

8 In States indicated by star (*) law provides that allotments for work on local roads or streets may also be used for service of local highway obligations, but amounts so used not reported separately.

9 In a number of States allotments for local road work may be used on city streets. This column shows allotments which were reported separately. See note 6.

10 To State general funds unless otherwise noted. Allocations to county or municipal general funds may have been used in part for highways, but such amounts not reported.

11 To county and municipal general funds.

12 For engineering expenses in connection with irrigation.

13 Funds allotted to counties for use on both State and local roads.

14 Pro-rata share of State highway sinking fund transferred to general fund as a result of refunding operation which replaced sinking fund bonds with serial bonds.

15 For Confederate pensions and past-due teachers' salaries, $190,755; prison camps, $317.

VEHICLE RECEIPTS, 1935

of State authorities]

For local roads and streets [8]				For other highway purposes (park and forest roads, etc.)	For nonhighway purposes					State
For work on county and local roads [8]	For work on city streets [9]	Service of local highway obligations	Total		To general funds [10]	For relief of unemployment or destitution	For education	For other purposes	Total	
					[11] $653,183				$653,183	Alabama.
								[12] $1,356	1,356	Arizona.
										Arkansas.
*$2,920,044			$2,920,044							California.
[13] 802,721			802,721		730,476	$253,801			984,277	Colorado.
2,174,538			2,174,538							Connecticut.
					[14] 332,606				332,606	Delaware.
							$4,405,359		4,405,359	Florida.
					91,882			[15] 191,072	282,954	Georgia.
*1,516,754			1,516,754							Idaho.
1,187,635			1,187,635		144,968				144,968	Illinois.
1,272,836	$318,209		1,591,045		2,102,591				2,102,591	Indiana.
										Iowa.
942,534			942,534							Kansas.
516,007			516,007							Kentucky.
										Louisiana.
371,745			371,745							Maine.
	637,894		637,894			326,461			326,461	Maryland.
1,467,761			1,467,761	$332,930		[16] 280,711			280,711	Massachusetts.
*15,959,812			15,959,812		346,751				346,751	Michigan.
					89,052				89,052	Minnesota.
*1,469,542			1,469,542							Mississippi.
										Missouri.
1,151,818	28,514		1,180,332							Montana.
1,342,447			1,342,447							Nebraska.
										Nevada.
		[17] $115,022	115,022							New Hampshire.
6,894,896		1,154,266	8,049,162							New Jersey.
146,412			146,412		[19] 390,432				390,432	New Mexico.
*9,168,706			9,168,706		[21] 19,416,297				19,416,297	New York.[20]
[22] 1,781,725			1,781,725		272,924				272,924	North Carolina.
16,342			16,342					[23] 905,000	905,000	North Dakota.
[24] *15,178,280	([25])		15,178,280					[26] 239,630	239,630	Ohio.
*1,990,916			1,990,916							Oklahoma.
*356,686			356,686	6,323						Oregon.
	538,919		538,919	43,316				[28] 35,538	35,538	Pennsylvania.
						370,389			370,389	Rhode Island.
										South Carolina.
1,030,101			1,030,101	8,533						South Dakota.
						138,376		[29] 1,487	139,863	Tennessee.
*9,809,143			9,809,143							Texas.
										Utah.
634,335			634,335							Vermont.
								[27] 628	628	Virginia.
11,924			11,924							Washingon.
[22] 641,663			641,663		[30] 2,392				2,392	West Virginia.
2,277,770	328,915		2,606,685	90,386	[31] 1,438,748				1,438,748	Wisconsin.
										Wyoming.
					[32] 747,561				747,561	District of Columbia.
83,035,093	1,852,451	1,269,288	86,156,832	481,488	26,759,863	1,369,738	4,405,359	1,374,711	33,909,671	Total.

[16] Pro-rata share (approximate) of debt service on nonhighway portion of Emergency Public Works loan.
[17] Pro-rata share service of highway relief bonds, a State obligation incurred for improvement of local roads.
[18] Includes $4,594,247, pro-rata share of temporary loan to general fund for relief.
[19] To State general fund, $146,412; to county general funds, $244,020.
[20] Appropriations out of general fund for highway purposes have been credited against payments of motor-fuel tax and motor-vehicle fees to the State general fund and prorated in proportion to net receipts not otherwise dedicated.
[21] To State general fund after crediting appropriations for highway purposes, $15,213,905; New York City general fund, $4,202,392.
[22] For county roads under State control.
[23] To real estate bond and interest fund, $900,000; Bureau of Criminal Identification, $5,000.
[24] General law provides that this allotment shall be used for highway purposes. It is provided, however, that during 1933, 1934, and 1935 amounts shall be paid to counties and townships for other than highway purposes, equal to amounts which would have been produced by the 1930 levies on personal property for other than highway purposes. Amounts so diverted not reported.
[25] Allotments to municipalities not reported separately for 1935.
[26] For hospitalization of indigent persons injured in motor-vehicle accidents.
[27] In computing adjustment, amounts loaned to general fund for relief purposes in 1934 and 1935 (pro-rata share, $3,717,186) have been included in the undistributed balances.
[28] For aircraft landing fields, $24,021; cooperative work other departments, $11,517.
[29] For aviation purposes.
[30] To cities.
[31] To towns, cities, and villages in lieu of personal property tax formerly imposed on motor vehicles.
[32] To District of Columbia general fund.

DISPOSITION OF STATE MOTOR-

[Compiled from reports

State	Net total receipts of calendar year	Adjustments due to undistributed balances, etc.[1]	Net total funds distributed [2]	Expenses of collection and administration	For State highway purposes						
					Construction, maintenance, and administration [3]	State highway police	Service of State highway obligations				Total for State highway purposes
							State highway bonds	State assumed local obligations [4]	Notes and other short-term loans	Total	
Alabama	$109,592	−$14,335	$95,257	$23,142	$54,749						$54,749
Arizona	122,394	−3,246	119,148	10,653	103,930	$4,350					108,280
Arkansas	2,038		2,038		392		$769	$857	$20	$1,646	2,038
California	2,014,661	661,925	2,676,586	380,038	276,818		460,000			460,000	736,818
Colorado	294,473	−33,942	260,531	40,432	141,314						141,314
Connecticut	167,974	−16,059	151,915		48,540						48,540
Delaware	(11)										
Florida	221,216		221,216	47,227							
Georgia	298,705	−37,694	261,011	133,475	93,996						93,996
Idaho	77,231	−28,845	48,386	20,480		27,906					27,906
Illinois	(13)										
Indiana	513,783	−267,921	245,862	69,774	176,088						176,088
Iowa	431,419	−9,449	421,970	112,936							
Kansas	867,992	1,730	869,722	227,583	346,647	88,863		44,919		44,919	480,429
Kentucky	269,984	−80,050	189,934	74,985	114,664	285					114,949
Louisiana	1,142		1,142	1,142							
Maine	20,288		20,288	20,288							
Maryland	(14)										
Massachusetts	64,815		64,815	37,127							
Michigan	387,171	−298,939	88,232	87,152							
Minnesota	18,798	230	19,028	19,028							
Mississippi	100,250	−4,946	95,304	1,300							
Missouri	447,609	40,082	487,691	64,893	217,353	5,530	164,710			164,710	387,593
Montana	22,164	−3,695	18,469	18,469							
Nebraska	(11)										
Nevada	192,310		192,310	8,553	180,532	3,225					183,757
New Hampshire	2,821		2,821	2,821							
New Jersey	84,253	[15] −28,292	55,961		18,564						18,564
New Mexico	87,001	−3,397	83,604	11,400	59,470	12,734					72,204
New York	(11)										
North Carolina	132,687		132,687		41,595	1,297	47,673	2,882		50,555	93,447
North Dakota	52,373	−28,936	23,437	23,437							
Ohio	727,874		727,874	155,240	439,881	9,958					449,839
Oklahoma	796,776	−19,349	777,427	37,126	740,301						740,301
Oregon	752,177	32,485	784,662	100,380	316,787	22,902	243,522			243,522	583,211
Pennsylvania	7,635	[17] −430	7,205		5,119	178	746			746	6,043
Rhode Island	14,976		14,976	14,976							
South Carolina	87,882	−3,499	84,383	16,347	60,761						[7] 60,761
South Dakota	312,435	66,413	378,848	28,200	339,701						339,701
Tennessee	265,537	20,608	286,145	62,341	135,269		3,268		1,745	5,013	140,282
Texas	64,586	−700	63,886	54,404	9,482						9,482
Utah	267,412	1,408	268,820	31,439	228,530	8,851					237,381
Vermont	(11)										
Virginia	138,460		138,460	19,914	92,049						92,049
Washington	186,126		186,126	186,126							
West Virginia	59,632		59,632		15,729		41,536			41,536	57,265
Wisconsin	1,429,481	−15,446	1,414,035	404,364							
Wyoming	138,268		138,268	23,271	112,356	2,641					114,997
District of Columbia	166,982		166,982								
Total	12,421,383	−74,289	12,347,094	2,570,463	4,370,617	188,720	962,224	48,658	1,765	1,012,647	5,571,984

[1] Amounts distributed during the calendar year differ in many cases from actual collections because of undistributed balances and lag between accounts of collecting and expending agencies.

[2] In many States the proceeds of motor-fuel taxes, motor-vehicle fees, and motor-carrier taxes are placed in a common fund from which the distribution is made. In these cases the amounts distributed have been prorated in proportion to the receipts, not otherwise dedicated, from these 3 sources of revenue. See preceding tables.

[3] Includes funds allotted for expenditure on urban extensions of State-highway system, where reported separately from other funds distributed for local roads and streets.

[4] County or local obligations assumed by State as reimbursement for local roads added to State system.

[5] In States indicated by star (*) law provides that allotments for work on local roads or streets may also be used for service of local highway obligations, but amounts so used not reported separately.

[6] To State general funds unless otherwise noted. Allocations to county or municipal general funds may have been used in part for highways, but such amounts not reported.

[7] For engineering expenses in connection with irrigation.

CARRIER TAX RECEIPTS, 1935

of State authorities]

For local roads and streets [5]				For other highway purposes (park and forest roads, etc.)	For nonhighway purposes					State
For work on county and local roads	For work on city streets	Service of local highway obligations	Total		To general funds [6]	For relief of unemployment or destitution	For education	For other purposes	Total	
$17,366			$17,366							Alabama.
								[7] $215	$215	Arizona.
										Arkansas.
277,220			277,220		$1,268,170			[8] 14,340	1,282,510	California.
[9] 78,785			78,785							Colorado.
					[10] 103,375				103,375	Connecticut.
										Delaware.
		$161,535	161,535		[10] 8,256		$4,198		12,454	Florida.
306			306		10,792			[12] 22,442	33,234	Georgia.
										Idaho.
										Illinois.
										Indiana.
[9] 309,034			309,034							Iowa.
161,710			161,710							Kansas.
										Kentucky.
										Louisiana.
										Maine.
										Maryland.
					27,688				27,688	Massachusetts.
					1,080				1,080	Michigan.
										Minnesota.
[9] 93,229			93,229		775				775	Mississippi.
35,205			35,205							Missouri.
										Montana.
										Nebraska.
										Nevada.
										New Hampshire.
29,876		7,521	37,397							New Jersey.
										New Mexico.
										New York.
[16] 34,028			34,028		5,212				5,212	North Carolina.
										North Dakota.
122,795			122,795							Ohio.
										Oklahoma.
[9] 99,311			99,311	1,760						Oregon.
	130		130		1,032				1,032	Pennsylvania.
										Rhode Island.
					[18] 7,275				7,275	South Carolina.
				10,947						South Dakota.
					76,646	6,803		[19] 73	83,522	Tennessee.
										Texas.
										Utah.
										Vermont.
					26,497				26,497	Virginia.
										Washington.
[16] 2,367			2,367							West Virginia.
					1,009,671				1,009,671	Wisconsin.
										Wyoming.
					[20] 166,982				166,982	District of Columbia.
1,261,232	130	169,056	1,430,418	12,707	2,713,451	6,803	4,198	37,070	2,761,522	Total.

[8] For service of county and city bonds.
[9] Funds allotted to counties for use on both State and local roads.
[10] To cities and towns.
[11] No special taxes on motor carriers reported.
[12] For Confederate pensions and past-due teachers' salaries, $22,405; for prison camps, $37.
[13] Receipts from weight tax on motor carriers, $5,154, included in motor-vehicle receipts, preceding table.
[14] Ton-mile and passenger-mile taxes paid by motor carriers in lieu of registration fees included in motor-vehicle receipts, preceding table.
[15] Adjustment includes $29,937, pro-rata share of temporary loan to general fund for relief purposes.
[16] For county roads under State control.
[17] Pro-rata share of temporary loan to general fund for relief purposes.
[18] To counties and cities.
[19] Aviation projects.
[20] To district of Columbia general fund.

DISPOSITION OF RECEIPTS FROM STATE

[Compiled from reports

State	Net total receipts of calendar year [1]	Adjustments due to undistributed balances, etc.[2]	Net total funds distributed	Expenses of collection and administration [3]	For State highway purposes						
					Construction, maintenance, and administration [4]	State highway police	Service of State highway obligations				Total for State highway purposes
							State highway bonds	State-assumed local obligations [5]	Notes and other short-term loans	Total	
Alabama	$13,996,855	−$18,499	$13,978,356	$445,179	$5,853,965	$172,964	$1,728,513			$1,728,513	$7,755,442
Arizona	4,249,138	−18,512	4,230,626	200,065	2,740,164	114,688					2,854,852
Arkansas	10,793,136	−15,798	10,777,338	448,059	1,856,242	86,280	3,643,547	$4,055,430	$93,311	7,792,288	9,734,810
California	52,561,118	−2,317,466	50,243,652	2,541,614	28,001,282	2,068,763	460,000			460,000	30,530,045
Colorado	8,510,936	−34,381	8,476,555	486,253	4,456,691	73,128					4,529,819
Connecticut	11,948,042	−175,283	11,772,759	894,699	8,275,147	325,000					8,600,147
Delaware	2,553,898	[14] 561,169	3,115,067	52,730	1,778,079	163,759	89,400	469,930		559,330	2,501,168
Florida	23,072,962	−10,813	23,062,149	617,069	7,581,351	58,957		2,552,247		2,552,247	10,192,555
Georgia	17,318,706	−37,694	17,281,012	816,257	8,345,288						8,345,288
Idaho	5,081,613	−118,426	4,963,187	88,457	3,069,880	80,971	207,125			207,125	3,357,976
Illinois	50,823,119	29,032	50,852,151	1,566,129	17,075,250	893,175	9,081,120	376,789		9,457,909	27,426,334
Indiana	27,930,395	−321,814	27,608,581	1,057,934	12,749,268	385,227					13,134,495
Iowa	22,294,583	−317,823	21,976,760	957,916	7,503,053			8,114,757		8,114,757	15,617,810
Kansas	13,324,758	18,992	13,343,750	865,555	7,697,555	180,640		1,000,000		1,000,000	8,878,195
Kentucky	13,597,315	−62,475	13,534,840	541,190	12,437,905	39,738					12,477,643
Louisiana	12,981,491	567,004	13,548,495	208,799	2,762,785	342,477	8,365,250			8,365,250	11,470,512
Maine	7,829,193	−2,424	7,826,769	152,552	4,398,749	250,000	2,110,307			2,110,307	6,759,056
Maryland	12,731,465	−259,198	12,472,267	336,460	4,519,627	260,699	2,521,146			2,521,146	7,301,472
Massachusetts	23,704,302	2,824	23,707,126	1,575,587	6,092,412	325,000	715,305		25,000	740,305	7,157,717
Michigan	40,778,840	−189,127	40,589,713	1,385,930	12,465,565	250,000	4,082,060			4,082,060	16,797,625
Minnesota	18,596,459	214,920	18,811,379	964,633	9,736,775	171,409	2,122,000	1,962,820		4,084,820	13,993,004
Mississippi	9,353,476	−7,729	9,345,747	187,467	4,449,754	27,506					4,477,260
Missouri	18,604,696	104,781	18,709,477	705,464	10,076,478	256,391	7,635,939			7,635,939	17,968,808
Montana	5,248,274	37,340	5,285,614	128,067	3,100,035	72,540	804,640			804,640	3,977,215
Nebraska	11,808,139	1,126	11,809,265	172,935	5,945,800	12,500					5,958,300
Nevada	1,417,861	−17,496	1,400,365	32,666	1,263,052	22,813	67,562	14,272		81,834	1,367,699
New Hampshire	4,562,489	210	4,562,699	109,914	3,298,487	136,700	731,848			731,848	4,167,035
New Jersey	34,913,118	[22] −6,032,485	28,880,633	1,194,186	3,343,211		7,597,651			7,597,651	10,940,862
New Mexico	4,082,185	−17,331	4,064,854	201,289	1,800,291	12,734	1,513,696			1,513,696	3,326,721
New York [25]	100,267,752	−114,118	100,153,634	2,536,357	11,944,018	1,149,150	8,737,780			8,737,780	21,830,948
North Carolina	25,916,450	650,433	26,566,883	353,237	7,979,927	248,825	9,146,145	553,007		9,699,152	17,927,904
North Dakota	3,798,455	−187,978	3,610,477	157,016	1,739,384	26,959					1,766,343
Ohio	61,432,603	−1,226,714	60,205,889	1,660,017	20,909,973	473,346					21,383,319
Oklahoma	16,535,293	−387,209	16,148,084	817,841	6,936,338						6,936,338
Oregon	11,443,279	−59,695	11,383,584	441,799	5,103,775	283,256	3,923,391			3,923,391	9,310,422
Pennsylvania	69,418,399	[33] −1,289,503	68,128,896	1,601,273	43,866,369	1,531,849	6,414,693			6,414,693	51,812,911
Rhode Island	5,021,642	56,865	5,078,507	291,417	3,813,464		301,876			301,876	4,115,340
South Carolina	10,644,681	−82,657	10,562,024	236,095	4,318,978	149,265	1,339,386	3,024,084	652	4,364,122	8,832,365
South Dakota	5,998,880	94,483	6,093,363	144,228	2,482,433						2,482,433
Tennessee	18,663,870	221,397	18,885,267	427,024	4,990,330	190,922	120,100	2,133,833	4,132,610	6,386,543	11,567,795
Texas	49,416,568	−87,991	49,328,577	1,285,306	21,345,965	308,041		8,290,061		8,290,061	29,944,067
Utah	4,052,400	−261,315	3,791,085	139,204	2,805,713	108,668	737,500			737,500	3,651,881
Vermont	3,425,886	1,427,761	4,853,647	46,691	2,584,430	73,309	949,131			949,131	3,606,870
Virginia	18,629,720	−137,428	18,492,292	525,363	10,922,651	194,960	649,679			649,679	11,767,290
Washington	16,249,758		16,249,758	549,971	6,671,974	507,098	[40] 97,930			97,930	7,277,002
West Virginia	10,983,210	−1,741	10,981,469	71,927	2,744,582	29,277	7,248,016			7,248,016	10,021,875
Wisconsin	28,576,260	−1,168,044	27,408,216	1,331,866	10,485,808			3,815,721		3,815,721	14,301,529
Wyoming	2,553,073	80,989	2,634,062	43,792	1,669,285	45,778	278,000			278,000	1,993,063
District of Columbia	3,274,417	374,793	3,649,210	162,665							
Total	950,971,158	−10,535,048	940,436,110	31,761,144	375,989,538	12,104,762	93,420,736	36,362,951	4,251,573	134,035,260	522,129,560

[1] Includes receipts from (1) motor-fuel taxes, (2) motor-vehicle fees and fines, and (3) special imposts on motor vehicles operated for hire (motor-carrier taxes). See preceding tables, which give distribution of these three classes of receipts separately.
[2] Amounts distributed during the calendar year differ in many cases from actual collections because of undistributed balances and lag between accounts of collecting and expending agencies. Adjustments also include deduction of receipts not classed as highway-user imposts as follows: Proceeds of tax on gasoline used in aviation in Idaho, Maine, Michigan, Nebraska, Oregon, and Wyoming, and proceeds of tax on nonmotor-vehicle fuel in Ohio.
[3] Includes expenses of collection and administration of motor-fuel tax, motor-vehicle fees, and motor-carrier taxes, and miscellaneous expenses of motor-vehicle regulation.
[4] Includes funds allotted for expenditure on urban extensions of State highway system, where reported separately from other funds distributed for local roads and streets.
[5] County or local obligations assumed by State as reimbursement for local roads added to State system.
[6] In States indicated by star (*) law provides that allotments for work on local roads or streets may also be used for service of local highway obligations, but amounts so used not reported separately.
[7] In a number of States allotments for local road work may be used on city streets. This column shows allotments which were reported separately. See note 4.
[8] To State general funds unless otherwise noted. Allocations to county or municipal general funds may have been used in part for highways, but such amounts not reported.
[9] To county and municipal general funds.
[10] For engineering expenses in connection with irrigation.
[11] For service of county and city bonds.
[12] Funds allotted to counties for use on both State and local roads.
[13] To cities and towns.
[14] State highway sinking fund transferred to general fund as a result of refunding operation which replaced sinking-fund bonds with serial bonds.
[15] Includes $8,256 to cities and towns.
[16] To Division of Airways, $15,616; Dade Memorial Park, $818.
[17] For Confederate pensions and past-due teachers' salaries, $2,000,000; prison camps, $3,322.
[18] To ports of New Orleans and Lake Charles Harbor for harbor improvement.
[19] To Conservation Department for oyster propagation, $75,000; Chesapeake Bay ferry companies, $48,727.
[20] Debt service on nonhighway portion of emergency Public Works loan.
[21] Service of highway relief bonds, a State obligation incurred for improvement of local roads.

IMPOSTS ON HIGHWAY USERS, 1935

of State authorities]

For local roads and streets [6]				For other highway purposes (park and forest roads, etc.)	For nonhighway purposes					State
For work on county and local roads	For work on city streets [7]	Service of local highway obligations	Total		To general funds [8]	For relief of unemployment or destitution	For Education	For other purposes	Total	
$5,124,552			$5,124,552		[9] $653,183				$653,183	Alabama.
*983,365			983,365			$186,667		[10] $5,677	192,344	Arizona.
512,731		$81,738	594,469							Arkansas.
*15,707,322	$182,161		15,889,483		1,268,170			[11] 14,340	1,282,510	California.
[12] 2,476,206			2,476,206		730,476	253,801			984,277	Colorado.
2,174,538			2,174,538		[13] 103,375				103,375	Connecticut.
					[14] 561,169				561,169	Delaware.
		5,266,030	5,266,030		[15] 2,560,504		$4,409,557	[16] 16,434	6,986,495	Florida.
2,537,319			2,537,319		963,349		2,615,477	[17] 2,003,322	5,582,148	Georgia.
*1,516,754			1,516,754							Idaho.
*7,756,878	*6,596,832		14,353,710		289,237	3,512,788	3,703,953		7,505,978	Illinois.
8,785,708	2,196,427		10,982,135		2,434,017				2,434,017	Indiana.
*5,401,034			5,401,034							Iowa.
3,600,000			3,600,000							Kansas.
516,007			516,007							Kentucky.
							934,592	[18] 934,592	1,869,184	Louisiana.
915,161			915,161							Maine.
779,019	2,950,062	642,106	4,371,187		12,960	326,461		[19] 123,727	463,148	Maryland.
3,840,500			3,840,500	$871,134	9,527,688	[20] 734,500			10,262,188	Massachusetts.
*22,053,997			22,053,997		352,161				352,161	Michigan.
*3,697,644			3,697,644		156,098				156,098	Minnesota.
*4,680,245			4,680,245		775				775	Mississippi.
35,205			35,205							Missouri.
1,151,818	28,514		1,180,332							Montana.
*4,243,632	321,180		4,564,812			1,113,218			1,113,218	Nebraska.
										Nevada.
		[21] 285,750	285,750							New Hampshire.
9,690,450		1,354,550	11,045,000			3,964,062	1,332,500	[23] 404,023	5,700,585	New Jersey.
146,412			146,412		[24] 390,432				390,432	New Mexico.
*17,259,477			17,259,477		[26] 58,526,852				58,526,852	New York [25].
[27] 6,528,280			6,528,280		1,757,462				1,757,462	North Carolina.
781,342			781,342		776			[28] 905,000	905,776	North Dakota.
[29] *22,506,475	[30] 4,929,445		27,435,920				9,487,003	[31] 239,630	9,726,633	Ohio.
*4,899,899			4,899,899		3,228			[32] 3,490,778	3,494,006	Oklahoma.
*1,600,000			1,600,000	28,363						Oregon.
*8,345,374	1,118,410		9,463,784	89,883	1,032	5,086,269		[34] 73,744	5,161,045	Pennsylvania.
						671,750			671,750	Rhode Island.
*1,352,684			1,352,684		[35] 140,880				140,880	South Carolina.
1,030,101			1,030,101	80,000	114,425			[36] 2,242,176	2,356,601	South Dakota.
4,232,978			4,232,978		76,646	250,000		[37] 2,330,824	2,657,470	Tennessee.
*9,809,143			9,809,143				8,290,061		8,290,061	Texas.
										Utah.
1,200,086			1,200,086							Vermont.
[38] 6,170,790			6,170,790		26,497			[39] 2,352	28,849	Virginia.
*6,523,604	994,320	[40] 79,574	7,597,498			[40] 825,287			825,287	Washington.
[27] 885,275			885,275		[41] 2,392				2,392	West Virginia.
5,667,153	818,351		6,485,504	200,000	[42] 5,089,317				5,089,317	Wisconsin.
597,207			597,207							Wyoming.
	2,572,002		2,572,002		[43] 914,543				914,543	District of Columbia.
207,716,365	22,707,704	7,709,748	238,133,817	1,269,380	86,657,644	16,924,803	30,773,143	12,786,619	147,142,209	Total.

[22] Includes $5,391,424 temporary loan to general fund for relief.
[23] For service of institutional construction bonds, $434,468; Department of Commerce and Navigation, $90,000, less credit for excess allocations in 1934, (−) $120,445.
[24] To State general fund, $146,412; to county general funds, $244,020.
[25] Appropriations out of general fund for highway purposes have been credited against payments of motor-fuel tax and motor-vehicle fees to the State general fund and prorated in proportion to net receipts not otherwise dedicated.
[26] To State general fund after crediting appropriations for highway purposes, $52,828,892; New York City general fund, $5,697,960.
[27] For county roads under State control.
[28] To real estate bond and interest fund, $900,000; Bureau of Criminal Identification, $5,000.
[29] Law provided for partial diversion of county and township allotments to general funds. Amounts so used not reported separately.
[30] Allotment from motor-fuel tax only. Municipal allotments from motor-vehicle fees not reported separately in 1935.
[31] For hospitalization of indigent persons injured in motor-vehicle accidents.
[32] For service of general State debt.
[33] In computing adjustment, amounts loaned to general fund for relief purposes in 1934 and 1935, $7,340,000, have been included in the undistributed balances.
[34] For aircraft landing fields, $49,845; cooperative work, other departments, $23,899.
[35] To State general fund, $133,605; to counties and cities, $7,275.
[36] For payments on real-estate bonds.
[37] Service of general-fund bonds, $2,116,489; Great Smoky Mountain Park bonds, $211,649; aviation projects, $2,686.
[38] For county roads under State control in all but three counties, $5,944,322; transferred to remaining three counties, $226,468.
[39] For aviation purposes.
[40] Debt service charges on $10,000,000 emergency relief bond issue prorated in proportion to allotments for State highways, local roads, and nonhighway purposes.
[41] To cities.
[42] Includes $1,509,671 to State general fund and $3,579,646 to towns, cities, and villages in lieu of personal-property tax formerly imposed on motor vehicles.
[43] To District of Columbia general fund

STATUS OF FEDERAL-AID HIGHWAY PROJECTS

1936 -1937

AS OF NOVEMBER 30, 1936

STATE	APPORTIONMENT	COMPLETED			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 5,208,287	$ 51,600	$ 25,800	9.0	$ 710,181	$ 355,090	20.1	$ 730,700	$ 365,350	35.3	$ 4,462,047
Arizona	3,564,709	1,777,992	1,378,202	98.3	1,019,637	807,343	41.2	254,800	179,220	7.3	1,199,944
Arkansas	4,275,929							1,765,401	1,764,739	60.0	2,511,190
California	9,508,671	3,259,773	1,884,211	88.9	9,341,966	5,348,228	246.7	2,778,299	1,599,878	60.3	676,354
Colorado	4,575,144	2,914,634	1,543,884	109.8	3,277,034	1,804,071	118.7	1,280,437	715,991	50.7	511,198
Connecticut	1,582,913	491,873	245,937	9.5	727,093	361,344	6.9	120,800	60,240	3.8	915,393
Delaware	1,218,750	305,920	152,960	30.3	339,069	164,048	9.9	436,402	204,962	14.8	696,780
Florida	3,315,558	831,120	415,560	27.5	598,555	299,273	19.3	542,200	271,100	20.9	2,329,625
Georgia	6,336,443	936,738	436,776	72.1	2,435,848	1,217,904	128.7	921,133	450,951	39.0	4,230,811
Idaho	3,065,304	1,927,993	1,145,730	235.2	1,450,283	867,845	73.8	406,340	243,151	22.6	808,578
Illinois	10,325,922	5,190,075	2,589,322	90.2	6,858,774	3,394,913	135.9	4,018,070	1,983,610	98.8	2,358,078
Indiana	6,184,258	4,294,269	2,143,161	133.3	2,769,971	1,384,046	88.5	3,657,650	1,828,258	88.2	828,792
Iowa	6,466,628	6,757,971	3,196,508	445.5	3,342,843	1,621,270	134.7	2,090,518	1,010,224	64.0	638,626
Kansas	6,631,085	2,903,124	1,500,886	599.0	4,629,975	2,288,486	357.5	2,212,052	1,106,010	114.7	1,735,703
Kentucky	4,611,955	2,185,437	1,071,030	142.0	974,931	487,466	23.8	872,456	431,784	41.2	2,621,676
Louisiana	3,557,930	1,463,014	729,308	52.9	1,204,776	602,374	41.3	593,690	296,845	13.1	1,929,403
Maine	2,177,197	1,904,831	951,618	58.7	799,888	399,944	18.5	295,120	147,560	8.6	678,075
Maryland	2,050,870				924,493	462,212	12.9	804,838	361,896	10.9	1,226,761
Massachusetts	3,485,364	333,935	166,968	3.1	4,490,403	2,195,201	17.5	14,206	7,102		1,116,093
Michigan	7,668,768	5,517,385	2,754,470	224.5	8,371,468	4,185,734	225.2	1,204,594	611,297	35.5	117,267
Minnesota	6,849,307	7,879,557	3,702,191	522.3	2,331,861	1,162,143	118.2	1,561,964	780,982	58.6	1,203,991
Mississippi	4,387,636				294,105	147,052	16.3	1,133,470	567,035	70.9	3,673,548
Missouri	7,601,200	3,456,539	1,724,004	422.8	6,537,120	3,267,422	241.3	2,529,454	1,390,349	119.2	1,219,426
Montana	5,122,333	3,760,971	2,105,635	384.1	2,697,817	1,510,508	172.3	649,237	325,316	29.2	1,180,875
Nebraska	5,167,930	2,593,781	1,294,944	164.9	2,801,922	1,406,543	284.0	61,709	30,855	4.8	2,435,588
Nevada	3,189,479	1,448,617	1,249,457	269.5	691,420	594,683	14.3	9,600	8,300	.5	1,337,039
New Hampshire	1,218,750	758,362	372,685	22.5	286,182	142,523	4.6	10,550	5,275		698,267
New Jersey	3,352,469	1,833,713	916,837	28.1	2,680,249	1,262,830	26.1	324,309	162,155	5.4	1,010,648
New Mexico	3,990,023	2,671,651	1,623,798	208.7	1,935,274	1,196,066	171.2	908,535	552,567	33.1	617,593
New York	12,306,710	5,511,336	2,734,167	116.2	15,312,574	7,545,887	260.2	2,310,688	1,146,199	28.6	880,457
North Carolina	5,879,466	1,989,822	994,050	254.2	2,705,079	1,325,591	247.6	1,905,773	883,086	76.1	2,676,738
North Dakota	3,918,269				400,450	212,950	.4				3,705,319
Ohio	9,131,204	1,474,536	737,268	26.9	6,737,210	3,183,286	71.2	587,960	292,480	5.8	4,918,170
Oklahoma	5,884,927	2,153,021	1,122,895	76.9	1,714,378	898,650	60.3	1,113,320	529,529	43.1	3,333,853
Oregon	4,089,711	2,348,344	1,416,769	92.9	2,983,384	1,777,026	104.1	577,124	324,210	24.1	571,706
Pennsylvania	10,695,448	5,289,095	2,644,102	89.8	7,762,600	3,873,366	105.8	2,735,688	1,355,849	37.8	2,822,131
Rhode Island	1,218,750	23,810	11,905	.3	593,768	296,884	6.6	486,757	243,379	4.2	666,582
South Carolina	3,381,337	32,682	15,000	8.7	3,235,070	1,309,620	239.1	1,818,052	718,750	124.8	1,337,967
South Dakota	4,078,647	1,396,263	784,004	188.6	73,791	51,239	16.4	379,240	207,880	48.9	3,035,523
Tennessee	5,268,270	1,915,051	955,398	80.3	857,474	428,732	33.0	302,878	151,439	10.0	3,732,701
Texas	15,548,821	9,281,213	4,629,891	526.8	5,658,953	2,825,805	264.3	2,668,582	1,330,044	167.0	6,763,081
Utah	2,826,960	1,995,520	1,428,579	137.9	537,531	386,605	34.2	586,439	394,547	38.8	617,229
Vermont	1,218,750	1,323,336	659,042	62.9	763,404	354,753	20.2	129,620	64,750	4.3	140,205
Virginia	4,559,200	2,157,864	1,076,576	85.8	2,144,464	1,072,229	97.9	1,954,728	977,360	55.8	1,433,034
Washington	3,904,738	2,926,718	1,540,903	100.9	2,634,116	1,383,771	127.4	391,112	205,100	6.8	774,964
West Virginia	2,716,754	398,060	199,030	22.5	1,134,980	567,473	36.1	779,046	389,523	17.3	1,560,728
Wisconsin	6,090,504	3,675,354	1,755,618	150.3	4,058,518	1,975,646	139.8	457,915	227,825	18.3	2,131,415
Wyoming	3,121,972	2,780,220	1,696,458	347.3	1,179,293	730,843	145.0	152,790	94,100	30.8	600,571
District of Columbia											
Hawaii	1,218,750				467,855	231,167	8.2	69,938	34,754	1.6	952,829
TOTALS	243,750,000	114,123,120	59,723,537	6,821.9	135,478,030	69,368,085	4,787.2	51,596,184	27,033,806	1,855.5	87,624,572

CURRENT STATUS OF UNITED STATES WORKS PROGRAM HIGHWAY PROJECTS

(AS PROVIDED BY THE EMERGENCY RELIEF APPROPRIATION ACT OF 1935)

AS OF NOVEMBER 30, 1936

STATE	APPORTIONMENT	COMPLETED			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Works Program Funds	Miles	Estimated Total Cost	Works Program Funds	Miles	Estimated Total Cost	Works Program Funds	Miles	
Alabama	$ 4,151,115	$ 954,131	$ 954,131	51.0	$ 3,050,432	$ 3,050,432	78.5	$ 68,086	$ 68,086	8.7	$ 78,465
Arizona	2,569,841	2,495,172	2,184,031	161.8	563,100	336,434	27.2				49,375
Arkansas	3,352,061	2,150,928	2,133,168	208.9	1,126,473	1,124,671	138.2	55,329	55,221	11.9	39,001
California	7,747,928	4,804,519	4,623,801	197.3	2,998,628	2,975,468	56.7	69,672	69,672	1.2	78,987
Colorado	3,395,263	1,892,021	1,885,276	93.1	239,486	239,469	11.0				1,270,518
Connecticut	1,418,709	166,679	159,804	.2	619,224	581,031	8.6	294,306	294,306	8.9	383,567
Delaware	900,310	183,996	180,518	33.3	575,071	467,425	29.5	106,430	106,420	4.0	145,946
Florida	2,597,144	769,624	769,624	34.4	1,712,444	1,712,444	64.3	70,781	70,781	.4	44,294
Georgia	4,988,967	439,350	438,662	29.0	660,818	660,818	42.3	469,634	469,634	33.9	3,419,853
Idaho	2,222,747	1,739,499	1,692,671	145.6	510,235	490,540	37.7	21,660	21,660	2.4	17,876
Illinois	8,694,009	6,488,432	6,454,609	357.8	2,005,885	2,005,885	96.7	219,610	219,610	16.6	13,905
Indiana	4,941,255	1,235,967	1,232,664	59.7	3,828,728	3,608,823	168.8	37,924	37,924	6.3	61,843
Iowa	4,991,664	2,129,684	2,043,503	306.4	3,076,433	2,928,585	205.8	72,044	18,200	7.0	1,376
Kansas	4,994,975	1,979,998	1,979,717	211.3	3,024,994	3,015,184	163.8				74
Kentucky	3,726,271	1,732,303	1,724,277	236.1	1,424,606	1,424,606	105.6	355,705	355,696	8.1	221,691
Louisiana	2,890,429	939,645	802,230	53.5	1,851,075	1,654,642	104.8	335,053	275,018	16.4	158,539
Maine	1,676,799	1,171,746	1,170,514	49.9	405,523	405,523	20.5	84,600	84,600	2.5	16,161
Maryland	1,750,738	186,296	186,296	10.7	663,463	623,593	13.0	626,424	502,954	17.9	437,896
Massachusetts	3,262,885	117,754	117,754	1.1	2,034,905	2,034,905	16.6	856,377	503,016	.7	607,210
Michigan	6,301,414	5,156,800	5,096,270	244.3	1,046,421	1,046,421	43.6	203,200	158,200	4.8	523
Minnesota	5,277,145	4,971,518	4,218,675	806.1	1,279,576	878,731	95.8	163,066	130,198	2.5	49,542
Mississippi	3,457,552	1,530,341	1,526,274	116.7	1,555,771	1,554,402	88.3	315,059	315,059	27.1	61,817
Missouri	6,012,652	3,251,055	3,219,982	685.8	2,405,820	2,289,863	90.2	602,777	435,632	1.7	67,175
Montana	3,676,416	3,261,295	3,260,629	184.7	371,674	363,704	10.6				52,083
Nebraska	3,870,739	1,966,679	1,922,319	202.5	1,579,504	1,578,000	155.2	118,088	118,088	12.2	252,333
Nevada	2,243,074	1,686,964	1,636,081	75.5	336,756	336,756	16.0	2,738	2,738	.3	267,498
New Hampshire	945,225	491,748	476,066	24.3	260,796	250,723	8.3	89,423	87,975	1.8	130,461
New Jersey	3,129,805	571,768	571,769	13.2	2,287,721	2,271,566	15.9	207,045	198,076	4.7	88,394
New Mexico	2,871,397	2,037,358	2,036,654	156.7	605,318	605,318	36.1	156,277	156,277	5.8	73,148
New York	11,046,377	6,148,781	5,862,919	116.5	4,976,630	4,848,730	51.4	328,700	328,700	2.5	6,028
North Carolina	4,720,173	1,282,143	1,282,143	85.0	3,069,133	3,036,544	182.7	300,671	234,131	19.4	167,355
North Dakota	2,867,245	1,202,148	1,200,622	182.7	1,298,432	1,294,997	122.9	154,511	154,511	20.2	217,115
Ohio	7,670,815	2,233,273	2,210,463	78.4	4,278,746	4,156,035	147.7	1,085,310	1,068,105	65.5	236,212
Oklahoma	4,580,670	1,597,823	1,587,446	137.9	1,904,258	1,902,575	198.8	769,949	757,963	46.3	332,687
Oregon	3,038,642	1,960,160	1,941,326	148.5	1,253,621	892,185	8.8	69,992	69,992	9.5	135,139
Pennsylvania	9,347,797	1,296,303	1,234,644	67.4	1,953,278	1,949,240	57.9	2,117,071	2,116,182	69.2	4,047,731
Rhode Island	989,208	730,630	720,034	15.4	259,501	259,501	3.4	9,673	9,673		
South Carolina	2,702,012	739,721	703,539	79.3	1,480,601	1,421,787	131.2	271,363	254,009	19.1	322,678
South Dakota	2,976,454	1,627,862	1,627,862	342.1	897,926	897,926	100.4	307,147	307,147	39.1	143,519
Tennessee	4,192,460	1,558,721	1,554,796	71.8	1,496,888	1,496,888	51.9	506,607	506,607	18.4	634,169
Texas	11,989,350	9,515,614	8,624,872	868.5	3,534,481	3,230,556	243.4	188,047	89,975	10.0	43,948
Utah	2,067,154	1,353,522	1,222,977	152.4	672,601	641,237	35.8	112,860	112,860	5.0	90,080
Vermont	924,306	784,678	687,532	18.8	237,731	193,455	3.0	33,020	19,910	.4	23,410
Virginia	3,652,667	2,602,384	2,526,123	829.8	767,689	767,509	180.9	189,806	189,806	31.8	169,230
Washington	3,026,161	2,449,980	2,220,078	155.2	838,107	692,716	8.3	92,098	92,098	1.2	21,269
West Virginia	2,231,412	194,382	194,382	11.8	1,801,289	1,797,745	67.9	128,465	127,732	10.3	111,553
Wisconsin	4,823,884	4,600,425	4,135,575	309.2	907,340	678,123	31.5	2,030	2,030	2.9	8,156
Wyoming	2,219,155	1,340,460	1,340,443	109.0	859,398	840,528	31.1				38,184
District of Columbia	949,496	909,101	909,101	8.5	46,898	21,660	.4				18,735
Hawaii	926,033	243,307	228,809	4.0	401,855	395,297	4.9	54,422	53,884	1.5	248,044
TOTALS	195,000,000	100,874,688	96,713,655	8,543.1	75,037,283	71,931,196	3,613.9	12,323,050	11,250,356	580.1	15,104,793

CURRENT STATUS OF UNITED STATES WORKS PROGRAM GRADE CROSSING PROJECTS

(AS PROVIDED BY THE EMERGENCY RELIEF APPROPRIATION ACT OF 1935)

AS OF NOVEMBER 30, 1936

STATE	APPORTIONMENT	COMPLETED					UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION					BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Works Program Funds	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Works Program Funds	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Works Program Funds	NUMBER: Grade Crossings Eliminated by Separation or Relocation	NUMBER: Grade Crossing Structures Reconstructed	NUMBER: Grade Crossings Protected by Signals or Otherwise	
Alabama	$ 4,034,617	$ 606,753	$ 606,753	11		4	$ 2,961,384	$ 2,961,384	36			$ 313,047	$ 313,047	3		8	$ 153,434
Arizona	1,256,099	618,960	614,726	7			566,261	554,816	6								86,557
Arkansas	3,574,060	1,135,951	1,131,634	29	4		1,726,085	1,723,087	22	1		662,597	661,542	8	1	29	57,797
California	7,486,362	2,946,841	2,840,344	19	6		4,467,380	4,329,593	25	2							316,426
Colorado	2,631,567	1,076,063	1,055,063	20			868,611	868,583	7	1							707,921
Connecticut	1,712,684						563,087	491,009	3	1	1	494,014	494,014	1	2		727,661
Delaware	418,239						143,486	120,000	1								298,239
Florida	2,827,883	660,331	658,600	5	4		1,431,369	1,430,789	17	2		456,292	456,292	7			282,202
Georgia	4,895,949	12,090	12,090	1			354,170	354,170	6	2		510,359	510,359	17			4,019,330
Idaho	1,674,479	824,073	821,481	13	1		413,637	413,637	6			64,486	64,486	1		18	374,874
Illinois	10,307,184	2,423,431	2,422,894	31			5,528,177	5,528,177	32	5		2,139,800	2,139,800	11	2		216,313
Indiana	5,111,096	497,831	497,831	8			4,373,258	4,250,139	35	11		399,720	363,120			162	6
Iowa	5,600,679	1,507,566	1,460,776	40	4		3,568,132	3,531,469	59	5		691,074	574,020	11		8	34,414
Kansas	5,246,258	682,865	682,865	9		1	4,572,084	4,516,657	47	1		46,736	46,736	2		3	
Kentucky	3,672,387	265,336	265,336	7	1		2,463,277	2,173,545	13	2		134,304	134,304	1	3		1,099,203
Louisiana	3,213,467						1,447,148	1,447,148	14	1		966,512	922,046	8	3		844,272
Maine	1,426,861	493,350	493,016	12			584,695	584,103	8			81,675	81,675	1		2	268,066
Maryland	2,061,751						615,019	615,019	4	3		921,502	899,033	3	2	19	547,699
Massachusetts	4,210,833	197,672	197,672	2	1		2,634,481	2,634,481	19	2		382,770	382,770	2			995,910
Michigan	6,765,197	2,231,975	2,231,975	26	4		4,554,297	4,509,797	19	4							23,425
Minnesota	5,395,441	2,334,936	2,206,491	51	8	38	3,061,801	2,893,610	35	4	3	56,140	56,140		1	1	239,200
Mississippi	3,241,475	207,504	207,504	8	3		2,331,184	2,331,184	42		1	56,000	56,000	4		3	646,786
Missouri	6,142,153	308,981	308,981	6			5,695,929	5,499,685	46			367,252	253,300	1		2	80,187
Montana	2,722,327	2,250,014	2,250,014	32	6		403,583	403,583	5								68,730
Nebraska	3,556,441	1,441,856	1,440,533	55	1		1,588,885	1,588,885	23	1	5	434,876	434,876	5	1	20	92,147
Nevada	887,260	370,830	370,830	8			531,025	512,800	2	1		3,630	3,630			5	
New Hampshire	822,484	151,745	151,745	1	2		350,493	350,493	6	2	1						320,246
New Jersey	3,983,826	59,838	59,838		1		2,478,788	2,467,743	17	1		163,319	163,319	1	2		1,292,927
New Mexico	1,725,286	665,807	665,807	12			865,128	865,127	5	1		194,352	194,352	2			
New York	13,577,189	1,801,823	1,797,023	9	7		9,957,801	9,701,755	31	31		256,120	256,120		4		1,822,291
North Carolina	4,823,958	579,548	579,548	9	6		2,272,573	2,257,073	27	9		1,108,520	1,108,520	10	2	61	878,817
North Dakota	3,207,473	399,891	399,891	12			1,765,711	1,764,711	29	3		456,190	456,190	10	1		586,681
Ohio	8,439,897						4,393,291	4,179,991	27	3		3,202,400	3,039,096	17	4		1,220,810
Oklahoma	5,004,711	1,208,387	1,208,387	26	1		1,918,749	1,918,749	22	3		385,124	385,124	6	2		1,492,450
Oregon	2,334,204	562,923	562,923	7	3		1,804,273	1,722,133	9	3	1	38,350	38,350	1		1	10,798
Pennsylvania	11,483,613	390,192	338,959	17			6,341,869	5,792,969	42	14	9	2,221,625	2,218,877	11	3		3,132,808
Rhode Island	699,691	398,464	398,464	2	1		277,805	276,739	2	1							24,488
South Carolina	3,059,956	441,975	434,323	11	2	3	1,416,102	1,405,024	26	6		218,406	218,356		1	51	1,002,253
South Dakota	3,249,086	568,566	568,566	17	1	5	1,508,246	1,508,246	37	2	9	325,656	325,656	5	1	17	846,619
Tennessee	3,903,979	260,278	260,278	6		6	1,548,820	1,548,820	21	2	3	563,646	563,646	9	1	13	1,531,235
Texas	10,855,982	2,739,082	2,739,082	48	8		6,915,308	6,908,931	78	5		765,488	765,487	3	1	170	442,483
Utah	1,230,763	87,218	85,828	1	1		1,015,391	998,743	14			93,695	93,695	2			52,496
Vermont	729,857	461,762	457,829	7	5		204,074	187,995	1	1	9	64,345	34,745	2		5	49,288
Virginia	3,774,287	853,786	782,923	23	3		1,343,569	1,304,569	15	7		551,960	551,959	10	4	11	1,134,837
Washington	3,095,041	868,175	863,344	15	3	5	1,964,763	1,964,338	8	8		4,290	4,290			2	263,070
West Virginia	2,677,937						1,225,701	1,225,676	11	2		493,227	493,227	10	1	4	959,033
Wisconsin	5,022,683	1,661,704	1,661,704	21	2		2,785,641	2,720,560	16	4		536,470	475,000		1		165,418
Wyoming	1,360,841	251,237	251,131	4			863,106	828,101	8								281,609
Dist. of Columbia	410,804						425,564	396,804	3								14,000
Hawaii	453,703						522,380	453,703	5								
TOTALS	196,000,000	37,507,610	37,045,002	648	89	62	111,613,591	109,016,343	992	157	42	20,825,969	20,233,199	185	43	615	29,705,456

PUBLICATIONS of the BUREAU OF PUBLIC ROADS

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. As his office is not connected with the Department and as the Department does not sell publications, please send no remittance to the United States Department of Agriculture.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1924. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1927. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1928. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1929. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1933. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1934. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1935. 5 cents.

DEPARTMENT BULLETINS

No. 583D . . Reports on Experimental Convict Road Camp, Fulton County, Ga. 25 cents.

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922. 15 cents.

TECHNICAL BULLETINS

No. 55T . . . Highway Bridge Surveys. 20 cents.

No. 265T . . . Electrical Equipment on Movable Bridges. 35 cents.

MISCELLANEOUS PUBLICATIONS

No. 76MP . . The Results of Physical Tests of Road-Building Rock. 25 cents.

Federal Legislation and Regulations Relating to Highway Construction. 10 cents.

Supplement No. 1 to Federal Legislation and Regulations Relating to Highway Construction. 5 cents.

No. 191 . . . . Roadside Improvement. 10 cents.

The Taxation of Motor Vehicles in 1932. 35 cents.

An Economic and Statistical Analysis of Highway-Construction Expenditures. 15 cents.

Highway Bond Calculations. 10 cents.

Single copies of the following publications may be obtained from the Bureau of Public Roads upon request. They cannot be purchased from the Superintendent of Documents.

SEPARATE REPRINT FROM THE YEARBOOK

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

A complete list of the publications of the Bureau of Public Roads, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to the U. S. Bureau of Public Roads, Willard Building, Washington, D. C.

CURRENT STATUS OF UNITED STATES PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED BY SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT (1934 FUNDS) AND BY THE ACT OF JUNE 18, 1934 (1935 FUNDS)

AS OF NOVEMBER 30, 1936

STATE	APPORTIONMENTS		COMPLETED				UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS	
	Sec. 204 of the Act of June 16, 1933 (1934 Fund)	Act of June 18, 1934 (1935 Fund)	Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	Estimated Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds
Alabama	$ 8,370,133	$ 4,259,842	$15,386,528	$ 8,304,382	$ 3,584,390	760.1	$ 394,771	$ 52,665	$ 339,310	15.8		$ 309,252	2.5	$ 13,085	$ 26,890
Arizona	5,211,960	2,641,935	8,981,796	5,204,512	2,605,036	542.9	12,500		12,500					7,448	24,399
Arkansas	6,748,335	3,428,049	10,922,752	6,633,093	3,320,347	619.3	143,231	70,019	72,991	4.0	$ 31,389	7,200	10.9	13,834	27,511
California	15,607,354	7,932,206	30,579,892	15,582,063	7,769,804	758.7	115,026		115,016			820		25,291	46,567
Colorado	6,874,530	3,486,006	11,257,208	6,870,681	3,441,857	639.0	6,619		6,619					3,849	37,530
Connecticut	2,865,740	1,454,868	4,514,547	2,758,269	1,312,944	74.0	59,618	59,618		.1				47,854	141,924
Delaware	1,819,088	923,395	2,680,794	1,818,804	815,188	128.3	109,467		105,524	1.6				284	2,682
Florida	5,231,834	2,661,343	8,897,748	5,175,534	2,344,564	305.6	254,979		230,665	4.0	56,300	67,339	.5		18,775
Georgia	10,091,185	5,113,491	13,210,656	9,317,893	3,168,476	743.7	1,076,521	408,689	667,832	81.9	84,072	165,358	3.6	280,531	1,111,825
Idaho	4,486,249	2,277,486	7,024,481	4,416,568	2,185,517	500.5	54,194		52,034	.1	60,771	1,886	.9	8,910	38,049
Illinois	17,570,770	8,921,401	25,748,361	16,893,752	7,817,218	708.4	1,789,642	594,209	1,068,172	15.8	37,300	7,100	12.8	45,509	28,911
Indiana	10,037,843	5,088,963	15,360,433	9,896,355	4,733,207	474.1	373,636	129,083	244,553	11.0		58,728		12,405	52,475
Iowa	10,055,660	5,118,361	15,454,949	10,054,900	4,797,361	1,222.2	340,073		321,000	5.1	499			261	
Kansas	10,089,604	5,117,675	15,427,520	10,089,600	4,996,668	1,132.3	126,993		61,887	13.1				4	59,120
Kentucky	7,517,359	3,818,311	11,961,870	7,448,139	3,571,867	807.7	275,154	59,003	214,500	8.0	8,569	23,250		1,649	8,694
Louisiana	5,828,591	2,963,932	8,982,708	5,731,008	2,592,759	252.5	318,465	56,549	198,434	13.4		128,372	5.2	41,034	44,367
Maine	3,369,917	1,711,586	5,244,109	3,346,879	1,669,075	193.5	22,234	15,000	7,234			26,540	1.4	8,038	8,737
Maryland	3,564,527	1,810,058	5,536,045	3,477,038	1,010,456	148.5	162,147		161,772	5.3		285,453	7.3	87,489	352,376
Massachusetts	6,597,100	3,350,474	9,869,513	6,552,734	2,659,290	115.2	420,416		420,416	.3		91,944	.1	44,367	178,824
Michigan	12,736,227	6,452,568	20,602,589	12,696,114	6,264,495	766.9	168,750	40,113	47,600	1.2		136,788	.4		3,685
Minnesota	10,656,569	5,425,551	16,091,251	10,514,422	4,745,392	1,632.0	479,903	58,110	376,135	17.2		34,800	.6	84,036	269,224
Mississippi	6,978,675	3,540,227	12,693,004	6,735,410	2,992,648	721.4	653,726	188,861	464,865	22.7	3,960	41,503	1.9	50,445	41,211
Missouri	12,180,306	6,173,740	17,411,196	11,637,146	4,720,320	1,436.7	2,178,630	471,210	1,334,260	15.1		62,100		71,949	57,061
Montana	7,439,748	3,769,734	11,799,994	7,425,476	3,701,189	1,058.4	56,546		56,546					14,272	11,999
Nebraska	7,828,961	3,964,364	12,828,547	7,813,593	3,604,469	1,018.3	282,047		274,622	27.8		63,537	5.9	15,368	21,736
Nevada	4,545,917	2,302,356	7,065,551	4,545,917	2,268,591	758.8	25,004		25,004			1,650			7,111
New Hampshire	1,909,839	969,462	3,003,046	1,904,951	950,495	78.3	4,174		4,174					4,888	14,793
New Jersey	6,346,039	3,220,879	8,255,287	6,046,046	1,607,061	82.0	1,964,004	120,518	1,409,346	14.1	82,145	99,275	.6	97,330	105,197
New Mexico	5,792,935	2,941,700	8,788,982	5,734,176	2,827,536	743.9	107,130		107,130	5.9		2,695		58,759	4,338
New York	22,330,101	11,327,921	38,763,582	21,778,431	10,094,963	815.4	1,751,430	399,810	982,899	8.3	133,947	162,275	1.3	17,913	87,784
North Carolina	9,522,293	4,840,941	14,891,750	9,159,957	4,505,525	1,342.1	365,770	291,910	73,860	15.3	51,017	200,873	8.1	19,408	60,683
North Dakota	5,804,448	2,938,967	8,367,434	5,609,002	2,025,164	2,094.0	486,658	114,325	350,874	49.2	15,703	101,140	17.0	65,418	461,789
Ohio	15,484,592	7,865,012	24,406,155	15,352,665	7,212,293	784.7	620,238	73,790	517,531	11.4	34,023	87,639	4.3	24,114	47,549
Oklahoma	9,216,798	4,685,180	14,535,440	9,146,565	4,303,265	804.9	182,756	67,007	115,749	1.5		174,301	.2	3,226	91,865
Oregon	6,106,896	3,097,814	9,882,293	6,039,064	2,923,060	467.6	95,469	11,308	84,161	1.2		27,241		56,525	63,352
Pennsylvania	18,891,004	9,590,788	28,714,652	18,496,822	8,746,721	1,050.6	516,605	96,463	377,896	6.0	153,388	158,223	4.3	144,331	307,948
Rhode Island	1,998,708	1,014,572	3,144,150	1,998,708	1,012,094	89.1									2,478
South Carolina	5,459,165	2,770,954	7,914,944	5,239,171	2,379,367	614.7	336,927	158,946	166,496	12.3	46,320	119,798	2.1	14,728	105,293
South Dakota	6,011,479	3,047,643	9,222,498	5,816,751	2,829,595	1,548.7	241,233	101,480	139,753	34.7		37,133	23.8	93,248	41,161
Tennessee	8,492,619	4,302,991	13,431,633	8,492,543	3,901,956	491.0	307,094		307,094	5.3		46,727	5.9	76	47,214
Texas	24,244,024	12,291,253	37,580,691	23,907,965	11,760,024	2,779.8	478,512	284,494	183,387	.2	12,000	24,929	8.0	39,564	322,914
Utah	4,194,708	2,132,691	7,337,875	4,160,916	2,094,401	590.9	70,718	32,292	38,290					1,500	
Vermont	1,867,573	948,007	3,166,369	1,867,452	942,672	141.0								121	5,335
Virginia	7,416,757	3,765,387	11,651,923	7,293,588	3,410,217	607.9	267,062	37,959	211,441	34.1	50,946	59,917	7.4	34,263	83,813
Washington	6,115,867	3,106,412	9,400,613	6,112,042	3,025,446	302.7	46,596		46,596			14,823	.3	3,825	19,547
West Virginia	4,474,234	2,280,335	6,261,903	4,315,121	1,636,742	211.1	591,626	83,534	460,028	11.4		66,425	.7	75,579	117,140
Wisconsin	9,724,881	4,941,837	15,421,100	9,715,772	4,879,614	619.7	20,296		20,296			2,720		9,110	39,207
Wyoming	4,501,327	2,287,712	6,879,280	4,451,922	2,218,377	1,037.7	5,781	5,780		.3		33,085		43,625	36,250
District of Columbia	1,918,469	973,842	2,887,584	1,918,469	968,979	22.3									4,863
Hawaii	1,871,062	949,778	2,693,451	1,870,383	264,953	51.1	650,838		646,859	4.8		14,000		679	23,966
TOTALS	354,000,000	200,000,000	622,136,677	387,368,764	179,213,648	34,890.2	19,011,209	4,082,745	13,123,351	479.6	862,349	2,946,839	138.0	1,686,142	4,716,162